ADOLESCENT GIRLS' EMPOWERMENT AND NUTRITION IN LOW- AND MIDDLE-INCOME COUNTRIES

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DEDICATION

To John and my family.

ABSTRACT

Background: Adolescent girls in low- and middle-income countries (LMICs) are disproportionately affected by malnutrition due to biological and social factors, including gender inequities. Empowering adolescent girls may contribute to improving their nutritional status in settings where gender inequality persists, but the causal pathways through which empowerment contributes to improved nutrition for adolescent girls are not fully understood.

Thesis objectives: (1) To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs and (2) To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs.

Methods: A theoretically informed model of the empowerment–nutrition relationship was developed to inform this thesis. To answer objective 1, a Campbell systematic review of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs was conducted. To answer objective 2, a series of exploratory structural equation models of the relationship between dimensions of empowerment and measures of adolescent girls' nutritional status were developed and tested using cross-sectional Demographic and Health Survey data for adolescent girls in East Africa.

Results: The current evidence base on the empowerment–nutrition relationship for adolescent girls in LMICs is limited. This thesis found that there is a statistically significant relationship between empowerment and nutrition for adolescent girls that varies according to individual and contextual characteristics. It further found that there is limited, low-quality evidence that empowerment-based nutrition interventions contribute to improved nutritional status among adolescent girls in LMICs, though the evidence base is scarce, heterogenous, and lacking in methodological quality. A model of the causal pathways from empowerment-based nutrition interventions to improved nutritional status was developed.

Conclusion: This thesis provides a comprehensive examination of existing evidence of the relationship between adolescent girls' empowerment and nutrition in LMICs. This relationship is significant and complex, requiring careful consideration when designing interventions. The models that were developed, tested, and refined through this research are important contributions to the literature that can guide further research to improve measurement of the empowerment–nutrition relationship and the design and evaluation of interventions to empower adolescent girls for improved nutrition.

EXECUTIVE SUMMARY

Background

Adolescence is the phase of life between childhood and adulthood from ages 10 to 19. It is marked by profound physiological, cognitive, emotional, and psychosocial development. Growth during adolescence is second only in magnitude to that achieved during the first 1,000 days of life.[1] Proper nutritional support during adolescence is crucial for optimal growth and development — yet is out of reach for many.

The drivers of malnutrition among adolescents are multi-factorial. Individual behaviours such as food choice, dietary intake, and physical activity are influenced by the food environment, which in turn is shaped by household and community dietary and activity patterns, economic development, urbanization, and food and agriculture systems.[1] Poverty and food insecurity can particularly affect young people because they have fewer resources to draw from or to withstand shocks brought on by crises, such as COVID-19.[2] For adolescent girls, *gender inequality and restrictive gender norms* play a specific role in their vulnerability to malnutrition, as elaborated below.

The Global Strategy for Women's, Children's, and Adolescents' Health (2016-2030) pledges to end all forms of malnutrition and address the nutritional needs of children, adolescent girls, and pregnant and lactating women.[3] The strategy identifies gender equality as critical to women's and girls' ability to make informed choices about their health and to seek and receive the services they want and need. Supporting adolescent girls' ability to set, act on, and achieve strategic life goals, particularly in contexts where this was previously denied, is more generally referred to as the process of empowerment.[4] Empowering adolescent girls is a necessary component of any comprehensive approach to ending malnutrition in this vulnerable group.

The relationship between adult women's empowerment and maternal and child nutrition outcomes is well established.[5–8] This evidence base demonstrates that different dimensions of empowerment (e.g., household decision-making, financial autonomy, freedom of movement, etc.) are associated with different maternal and child health and nutrition outcomes. However, the evidence base for adolescent empowerment and nutrition is sparser. The causal pathways through which empowerment contributes to improved nutrition for adolescent girls has yet to be fully understood and articulated. Given the unique challenges and opportunities presented by adolescence for nutritional and developmental gains, understanding the nutrition-empowerment relationship is imperative. In the following chapters, this thesis will explore some of these key evidence gaps.

This body of work explores the relationship between adolescent girls' empowerment and their nutritional status in the context of low- and middle-income countries. Its goal is to help readers understand how and why empowerment is critical to adolescent girls' nutrition, and to identify empowerment-based programming approaches that can be leveraged to reduce malnutrition and meet the nutritional needs of adolescent girls.

Thesis objectives

This thesis addresses the following objectives:

1. To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs, and
2. To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs.

Summary of Objective 1

To achieve objective 1, a mixed methods Campbell systematic review was conducted. The primary objective of the review was to answer two questions:

(RQ1) What is the effect of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries?

(RQ2) What are the implementation and contextual factors influencing the success or failure of these interventions?

Secondary review questions were:

(RQ3) What are the underlying empowerment-related programme theories applied to intervention design? How is empowerment defined, operationalized, and measured?

(RQ4) What is the effect of empowerment-based nutrition interventions on the empowerment of adolescent girls?

(RQ5) What are the potential adverse effects of an empowerment-based approach on adolescent girls' health and well-being?

Methods

The review applied a segregated mixed methods research synthesis design (MMRS). A comprehensive search strategy was developed with the assistance of an information specialist. Databases were searched

up to Sept. 2021 included Ovid MEDLINE®, Embase, PsycINFO, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and CINAHL. Grey literature and handsearching were conducted up to 2023.

The review target population was adolescent girls (10-19y) residing in LMICs. For RQ1, eligible interventions were empowerment-based nutrition interventions to improve dietary intake, defined by the review's logic model. Eligible study designs were randomized and non-randomized studies with at least one comparison group. The primary outcome of interest was nutritional status (e.g., BMI).

For RQ2, eligible studies were quantitative or qualitative study designs that assessed the implementation or contextual factors of studies included in RQ1. Qualitative and quantitative studies were analysed and synthesised separately, while the implications for practice, policy, and research that form the discussion and conclusion sections of the review draw on both the qualitative and quantitative syntheses.

To answer RQ3-5, data were extracted from the studies included in RQ1.

Study selection, data extraction and quality assessments were conducted in duplicate by two independent reviewers. Quantitative data were synthesised using random effects meta-analysis or narrative synthesis. The "best-fit" framework synthesis method was used to synthesize qualitative findings.

Results

(RQ1) Four randomized controlled trials and six non-randomized studies were included. The review found limited, low-quality evidence that empowerment-based nutrition interventions may lead to little/no improvement in adolescent girls' body mass index, waist circumference, haemoglobin, anemia risk, and total dietary intake. The existing evidence base is largely limited to interventions to prevent or treat obesity among adolescent girls in middle-income countries. Overall, the evidence base is sparse, heterogenous, and of varying methodological quality.

(RQ2) One qualitative study and one quantitative study were included. Implementation factors that may contribute to intervention success include adapting the intervention to the local context and culture, training intervention providers, ensuring adequate availability of personnel, facilities, and materials, providing material incentives to adolescent girls to encourage participation, tailoring content to the education level of the participants, and pilot testing the intervention. Contextual factors that may affect intervention success are the socio-economic status of the community, food availability, and general insecurity. The review's logic model was revised (Figure 1) to incorporate findings from RQ1 and RQ2.

(RQ3) Eight studies used theoretical frameworks to inform intervention design that include concepts related to empowerment, but no studies provided a definition of empowerment or described an approach

to operationalizing empowerment. Three studies applied social cognitive theory (SCT), one study used the health competence model, two used Pender's health promotion model, and two studies applied the PRECEDE model.

(RQ4) Six studies assessed self-efficacy, a concept closely related to empowerment. Empowerment-based nutrition interventions may increase/have little to no effect on self-efficacy, but the evidence is very uncertain.

(RQ5) One study assessed potential harms. They reported no harm or unintended effects were observed in either group that could be directly attributed to the intervention.

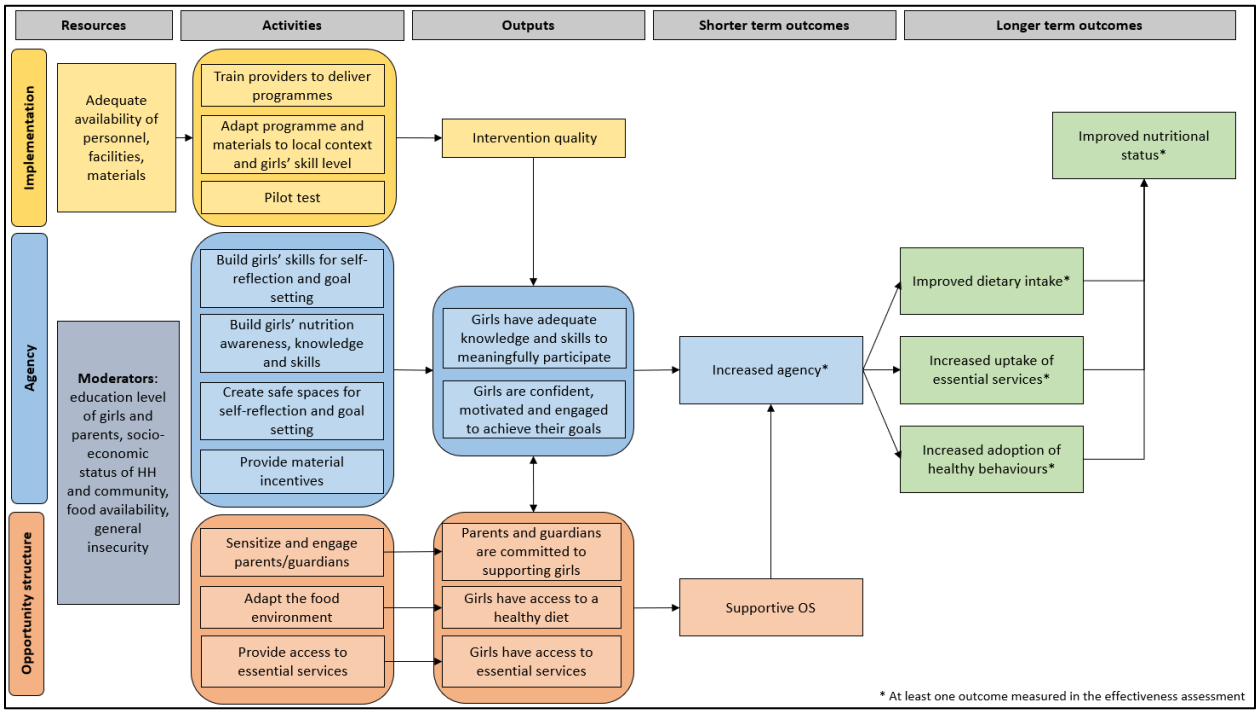


Figure 1. Revised logic model of the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status.

Conclusion

To the authors' knowledge, this is the first systematic review to examine the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs. The evidence on empowerment-based nutrition interventions to improve the nutritional status of adolescent girls in LMICs is inconclusive. The quality of the evidence was rated as moderate to very low. Outcome quality was downgraded due to study limitations, including unclear sequence generation and allocation concealment methods, lack of blinding, high heterogeneity, and imprecision.

Future studies assessing empowerment-based nutrition interventions among adolescents should focus on assessing the effectiveness of interventions in low-income countries where challenges related to undernutrition remain prominent. Studies should also be undertaken in the community and other non-school settings. Studies that target boys and girls should sex-disaggregated their results and reporting. Study quality needs to be improved with careful attention to managing selection bias and confounding, blinding assessors and analyses, and transparent outcome and analysis reporting. Further study of the implementation and contextual factors that contribute to intervention success is needed. Finally, standardized tools and measures for dietary intake, health behaviours, and empowerment are needed.

Summary of Objective 2

To answer research objective 2, a series of exploratory structural equation models (ESEM) of the relationship between dimensions of empowerment and measures of adolescent girls' nutritional status were developed and tested using cross-sectional Demographic and Health Survey data for married and single adolescent girls in East Africa.

Separate models for single and married adolescent girls were developed for two reasons. First, single versus married adolescent girls likely face different challenges or opportunities to their empowerment and nutrition because they are at different life stages. An area of inquiry was to understand how these different life stages affect empowerment and nutrition. Second, the dataset provided more empowerment-related measures for married respondents compared to single respondents. Given the much larger sample size of single adolescent girls, single country models were developed and sub-group analyses were conducted that examined differences based on girls' in-school status and geographic location, which were not possible with the married adolescent girls sample.

Because empowerment is complex and multidimensional, it can be difficult to measure directly. Exploratory structural equation modelling (ESEM) was used to capture the complexity of empowerment by using multiple indicators to measure capabilities as latent constructs. Structural equation modelling (SEM) is a group of statistical procedures used for causal inference that tests hypotheses regarding the linear relations among observed variables and latent constructs, making it appropriate to measure a complex and multidimensional construct such as empowerment that cannot be directly observed.[9] The main benefit of ESEM is its allowance for observed variables to cross-load onto more than one factor, thus preventing the inflation of factor correlations and biased estimates.[10] This flexibility is needed for measuring empowerment because much debate remains regarding optimal approaches to its measurement.[11]

Married adolescent girls

Methods

The study used cross-sectional Demographic and Health Survey (DHS) data from Ethiopia (2016), Kenya (2014), Tanzania (2015-16) and Uganda (2016) to construct and test theoretically informed structural equation models (Figure 2) of the relationship between six dimensions of empowerment and BMI-for-age and haemoglobin levels for married adolescent girls aged 15-19 years. Independent variables for adolescent girls' country of residence, household wealth, breastfeeding status and pregnancy status were included in the model as covariates. The dimensions of empowerment assessed were:

1. Access to information
2. Access to healthcare
3. Role in household decision-making
4. Rejection of justifications for intimate partner violence
5. Asset ownership
6. Social independence

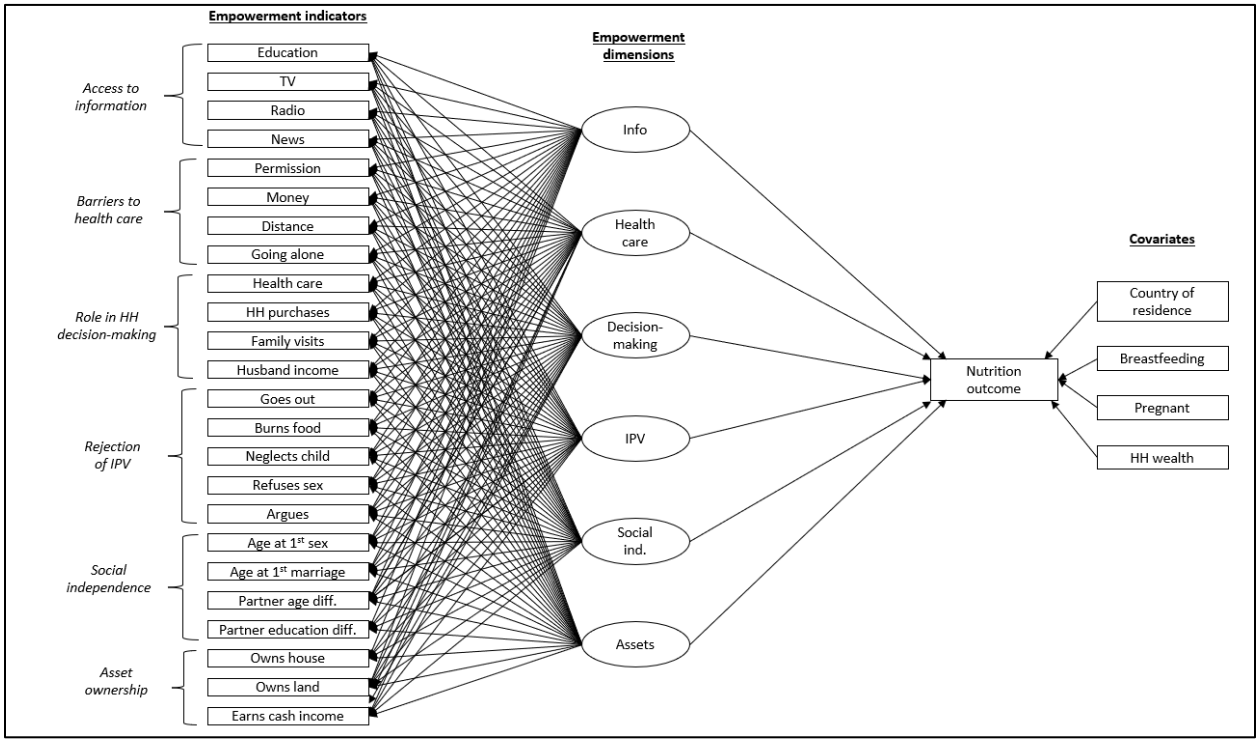


Figure 2. Exploratory structural equation model of the relationship between dimensions of empowerment and nutrition status, controlling for important covariates.

Notes: Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment dimensions). Unidirectional arrows represent direct effects of exposure on outcome. The lefthand

side of the model is an exploratory factor analysis of empowerment indicators to define the underlying factor structure (empowerment dimensions). The righthand side of the model is a regression analysis of a nutritional outcome on empowerment dimensions. Both sides of the model are estimated simultaneously. Not shown: Error terms for estimated variables, covariance of factors.

Results

The total sample size was 1,927 married adolescent girls. Almost 22% of respondents were pregnant and 41.2% were breastfeeding at the time of the surveys. The mean BMI of non-pregnant respondents was 20.8 kg/m^2. The prevalence of thinness and overweight (including obesity) among non-pregnant respondents was 3.5% and 7.0%, respectively. Almost 44% of respondents with available data were anemic.

The models were found to be a good fit for the data. Married adolescent girls' access to information, measured by their education level and mass media use, was directly and positively associated with their BMI-for-age ($p < 0.05$). Asset ownership, measured by owning a house or land alone or jointly, was directly and positively associated with haemoglobin ($p < 0.05$) and reduced odds of being moderately to severely anemic. Rejecting justifications for intimate partner violence, a measure of respondents' intrinsic agency, was directly and positively associated with the odds of being overweight or obese. Adolescent girls' level of empowerment across all dimensions had a direct relationship with their country of residence and household wealth.

Conclusion

The findings suggest that investment in girls' access to information through education and mass/social media and their economic empowerment may be important contributors to their overall empowerment and nutritional status. However, caution is needed as greater autonomy may contribute to increased consumption of unhealthy foods that can contribute to overweight and obesity. Strategies to empower married adolescent girls should be tailored to their specific circumstances. There is an urgent need for better data on adolescent empowerment and health, including increased research into age-, sex- and gender-appropriate empowerment measures and longitudinal data to assess causality. The use of statistical models should be complemented by robust qualitative research to further results interpretation.

Single adolescent girls

Methods

Cross-sectional Demographic and Health Survey data from five East African countries were used: Ethiopia (2016), Kenya (2014), Rwanda (2014-15), Tanzania (2015-16), and Uganda (2016). The study

population was single (never married) adolescent girls (15-19 years old) who were sampled for anthropometric measurements and anemia testing.

The primary outcome measures were haemoglobin and BMI-for-age. Country of residence and household wealth were included in the model as covariates (Figure 3). Three empowerment domains were assessed:

1. the ability to access information
2. the ability to access healthcare
3. the ability to reject intimate partner violence

Two prespecified subgroup analyses were conducted to assess differences between (1) respondents living in urban and rural settings and (2) respondents who reported attending school in the last year and those who did not.

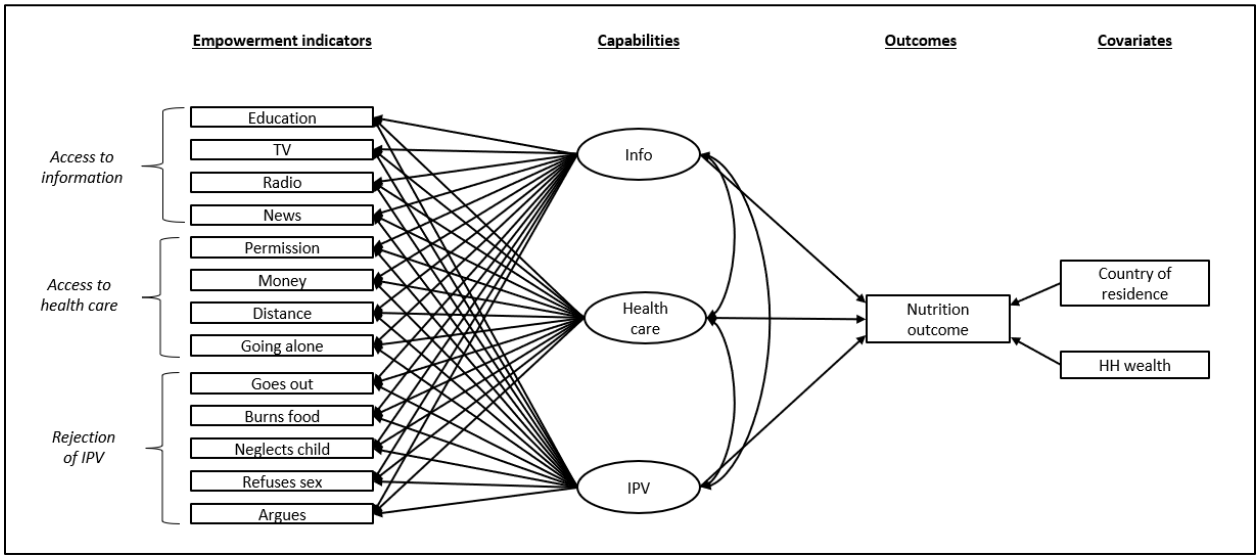


Figure 3. Exploratory structural equation model of the relationship between single adolescent girls' capabilities across empowerment domains.

Notes: Domains (Access to information, Access to healthcare, Rejection of intimate personal violence) and their nutritional status. Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment domains). Unidirectional arrows represent direct association between exposure on outcome. The lefthand side of the model is an exploratory factor analysis of empowerment indicators to define the underlying factor structure (empowerment domains / capabilities). The righthand side of the model is an adjusted regression analysis of a nutritional outcome on empowerment domains. Both sides of the model are estimated simultaneously. Error terms for estimated variables are omitted to simplify presentation. HH = Household, IPV = Intimate Partner Violence.

Results

The total sample included 9,849 respondents. Their mean age was 16.7 years and mean level of completed education was almost 7 years. Most respondents reported attending school in the last year

(63.5%) and one-third lived in an urban setting. Few respondents were either pregnant (1.2%) or breastfeeding (3.0%). Anemia affected just over 30% of the sample population. The prevalence of thinness was low (3.9%) while more than 12% of girls were overweight or obese. Half of respondents were from a household above the median wealth quintile. These statistics varied considerably by country.

The study found that girls' ability to access information was positively associated with their BMI-for-age and haemoglobin after controlling for household wealth and country of residence ($p < 0.05$). The remaining domains were not significantly associated with any nutrition outcomes. However, the relationship between girls' empowerment and nutritional status was more complex when subgroup differences (in-school status and geographic location) were examined. The relevant empowerment domains and the magnitude of their relationship with nutritional status changed according to these individual and contextual factors. When examining subgroup differences, the relationship between empowerment and nutrition was more complex. For example, living in a rural setting increased the magnitude of the positive relationship between the ability to access information and haemoglobin and BMI-for-age, while the same relationships were non-significant for girls living in an urban setting. Instead, the ability to access healthcare by overcoming common gender-related barriers to health care, such as permission and cost, was positively associated with haemoglobin levels for girls living in an urban setting, but non-significant for BMI-for-age.

Conclusion

These findings agree with existing literature that the empowerment process is highly dependent on an individual's characteristics and context, and that interventions to address adolescent girls' empowerment and nutrition need to consider their specific characteristics and circumstances that contribute to their disempowerment and increase their vulnerability to poor health, such as geographic location, socioeconomic status, and level of education. Applying an intersectional lens to understanding adolescent girls' marginalization can help to elucidate how individual identities combine with structural challenges to contribute to disempowerment and poor nutrition. Engaging adolescents through participatory research and program design is one way to support nutrition programs to adopt relevant empowerment strategies that meet their needs and priorities.

Overall thesis discussion and conclusion

A summary of the key thesis findings is provided in Table 1.

Table 1. Summary of key thesis findings.

Research objective	Chapter	Key findings
To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs.	Chapter 3 *Mixed methods systematic review*	• There is currently limited/no evidence that empowerment-based nutrition interventions contribute to improved nutritional status among adolescent girls in LMICs, but the evidence base is scarce, heterogenous, and largely lacking in methodological quality. • The existing evidence base is largely limited to interventions to prevent or treat obesity among adolescent girls in middle-income countries. • Heterogeneity in intervention design, along with a lack of standardized measures for empowerment, dietary intake, and nutrition behaviours, make it difficult to synthesize results across studies. • Many studies lack sufficient methodological quality, lowering the confidence that the true intervention effect is represented by current evidence. • More research is needed into the implementation and contextual factors that contribute to intervention success. • Adolescent nutrition researchers need to sex-disaggregate their results and consider the sex and gender implications of their research. • Some important nutrition and empowerment outcomes along the causal chain are not currently measured in studies.
To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs.	Chapter 4 *Exploratory structural equation modelling*	• Married adolescent girls' ability to access information through education and mass media use is positively associated with their BMI-for-age. • Married adolescent girls' ability to own assets (i.e., owning a house or land either alone or jointly) is positively associated with haemoglobin and reduced odds of being moderately to severely anemic. • Married adolescent girls' level of empowerment is directly associated with their level of household wealth and the country they live in. • Greater autonomy may contribute to increased consumption of unhealthy foods that can contribute to overweight and obesity. • Strategies to empower married adolescent girls should be tailored to their specific circumstances. • There is an urgent need for better data on adolescent empowerment and health, including increased research into age-, sex- and gender-appropriate empowerment measures and longitudinal data to assess causality.
	Chapter 5 *Exploratory structural*	• Improving single adolescent girls' ability to access information is significantly and positively associated with haemoglobin and BMI-for-age, including

Research objective	Chapter	Key findings
	equation modelling	reduced odds of being anemic and increased odds of being overweight or obese. • The significance of different empowerment domains to girls' nutrition varies according to their geographic location (urban/rural) and in-school status. • Like married adolescent girls, level of empowerment is directly associated with single girls' level of household wealth and the country they live in. • Applying an intersectional lens and meaningfully engaging adolescent girls in intervention design using participatory methods is recommended.
Notes: LMIC = Low- and middle-income country.		

Implications for practice

Implications of this research for Canadian NGOs working in the field of adolescent nutrition and empowerment are:

1. There is clear evidence that empowerment and nutrition are interlinked for adolescent girls in LMICs, and therefore, including empowerment-based strategies in nutrition programmes should be considered.
2. The use of a logic model, modelled after Figure 1, should be adopted at the programme design phase to clearly articulate the hypothesized pathways through which a programme's empowerment-based activities contribute to girls' improved empowerment and nutrition.
3. The theoretical model used to design an intervention or programme should be informed by a comprehensive assessment of the context- and individual-specific gender equality and social equity factors that contribute to adolescent girls' disempowerment and malnutrition and apply an intersectional lens.
4. Robust monitoring and evaluation plans should be developed for programmes; informed by the programme's theoretical model. Canadian NGOs can help to fill these evidence gaps by investing in high quality impact evaluations and implementation research. Careful thought should be given to identifying appropriate measures for concepts along the causal chain and measuring adverse effects.
5. Canadian NGOs should disseminate their findings so that the rest of the research and development assistance community can benefit from their experiences and lessons learned.

Considerations for Canadian policymakers

1. A stronger articulation of the government's policy to address adolescent nutrition that includes strategies to empower adolescent girls is needed as part of the Government of Canada Feminist International Assistance Policy.
2. The Government of Canada (GoC) should consider expanding its nutrition focus in the FIAP to include addressing the challenges of overweight and obesity. It is no longer practical to focus on undernutrition only; the double burden of malnutrition is growing in LMICs, particularly among the poorest.
3. The GoC should develop a research investment strategy to underpin its commitment to strengthening the evidence base for gender equality, as outlined in the FIAP. Within this research strategy, the government can commit to funding operational research conducted by Canadian and non-Canadian nutrition partners to better understand the empowerment–nutrition relationship.

Directions for future research

In this research, many important and novel findings were discovered, as described above. However, it also identified several areas of inquiry requiring further study and investigation. Two of these areas are:

1. Addressing measurement gaps along the empowerment–nutrition causal chain. research is needed to identify and validate measures of the components of empowerment (agency and opportunity structure) as they relate to adolescent nutrition, based on a conceptual framework, such as the one proposed here.
2. Undertaking high quality intervention studies in understudied populations and contexts. Rigorous experimental study design is needed to overcome some of the limitations found through the systematic review, such as selection bias, lack of blinding, and reporting bias. Studies are needed in low-income country settings where the triple burden of malnutrition remains prominent. Studies are also needed outside of school settings – targeting out-of-school youth. Studies that target adolescent boys and girls need to sex-disaggregate their findings.

Conclusion

This thesis provides a comprehensive examination of existing evidence of the relationship between adolescent girls' empowerment and nutrition in LMICs. It demonstrated that this relationship is significant and complex, requiring careful consideration when designing and evaluating interventions. The models that were developed, tested, and refined through this research are important contributions to the literature that can guide Canadian policymakers and NGOs in the investment, design, and evaluation of interventions to empower adolescent girls and improve their nutritional status. While many important

findings have been highlighted, important opportunities for future research are also identified, laying a solid foundation for further inquiry in this important area of research, policy and practice.

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CONTRIBUTION OF THE AUTHORS

Four manuscripts were prepared as part of this thesis (presented in Chapters 3-5), all of which have been published or submitted for publication.

All manuscripts were led by Alison Riddle and were co-authored by her two thesis supervisors (George A. Wells, Vivian Welch) and members of her thesis advisory committee (Zulfiqar A. Bhutta, Carol Vlassoff, Elizabeth Kristjannson, Monica Taljaard). Alison is the first author on all publications; she was responsible for study design, data collection, analysis, and manuscript writing. All studies were designed in consultation with members of the thesis advisory committee. Wenshan Li provided data preparation support for the exploratory structural equation modelling studies and is a co-author of the resulting publications. Olivia Magwood and Anita Rizvi provided screening, data extraction and quality assessment support for the mixed methods systematic review and is a co-author of the manuscript. Cynthia Kroeger and Abigail Kaplan Ramage contributed to the systematic review methods and screening and are co-authors of the resulting publications. Becky Skidmore developed and executed the systematic review search strategy and is an author on the resulting publications.

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I am honestly not sure where to begin. There are so many people I want to thank for helping me to get to this point – a point that I was often doubtful I would reach.

I guess the best place to start is at the beginning, when George Wells accepted to be my thesis supervisor following a call out of the blue. George, I have no words for how grateful I am for your consistent support, encouragement, patience, and brilliance. I learn something new and valuable every time we speak. Working with you has been a highlight of my career and I'm sure this won't be the end of our collaborations.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
BMIZ	Body Mass Index z-score
CFA	Confirmatory Factor Analysis
DHS	Demographic and Health Survey
DOT	Directly Observed Treatment
ESEM	Exploratory Structural Equation Model
FIAP	Canada's Feminist International Assistance Policy
GESI	Gender Equality and Social Inclusion
GoC	Government of Canada
Hb	Haemoglobin
IFA	Iron and Folic Acid
IKT	Integrated Knowledge Translation
LMIC	Low- and Middle-Income Country
MMRS	Mixed Methods Research Synthesis
NGO	Non-Governmental Organization
NRS	Non-Randomized Study
RCT	Randomized Controlled Trial
SCT	Social Cognitive Theory
SEM	Structural Equation Model
UGM	Unweighted Grand Mean
WRA	Women of Reproductive Age
ZBFA	BMI-for-age z-score

CHAPTER 1: Introduction

1.1 Rationale

Adolescence is the phase of life between childhood and adulthood from ages 10 to 19. It is marked by profound physiological, cognitive, emotional, and psychosocial development. Growth during adolescence is second only in magnitude to that achieved during the first 1,000 days of life.[1] Proper nutritional support during adolescence is crucial for optimal growth and development, yet it is out of reach for many. The prevalence of overweight (including obesity) among adolescents worldwide more than doubled between 2010 and 2020 to 20.2% for males and 18.4% for females.[2] Meanwhile, the prevalence of thinness declined only marginally (from 13.4% to 12.3% for males and from 8.1% to 7.9% for females).[2] Iron deficiency anemia affects approximately 619 million adolescents globally and is the leading cause of disability adjusted life years for adolescents.[3] Neglecting adolescent nutrition has negative repercussions for adolescents now, in the future, and for the next generation.[4]

The Global Strategy for Women's, Children's, and Adolescents' Health (2016-2030) pledges to end all forms of malnutrition and address the nutritional needs of children, adolescent girls, and pregnant and lactating women.[5] The strategy identifies gender equality as critical to women's and girls' ability to make informed choices about their health and to seek and receive the services they want and need. Supporting adolescent girls' ability to set, act on, and achieve strategic life goals, particularly in contexts where this was previously denied, is more generally referred to as the process of empowerment.[6] Empowering adolescent girls is a necessary component of any comprehensive approach to ending malnutrition in this vulnerable group.

There is general recognition that adolescent empowerment must be a priority in the context of adolescent health and nutrition programming. Key frameworks related to adolescent health and nutrition consistently include references to adolescent empowerment and agency.[1,7–9] Yet, there remain many questions about the exact causal pathways that characterise the empowerment – nutrition relationship. Empowerment is a complex and multidimensional construct that is challenging to define, operationalize, and measure. And while there is a growing body of evidence investigating the relationship between adult women's empowerment and maternal and child nutrition,[10–15] the specific case of adolescent girls is understudied.[16]

This body of work explores the relationship between adolescent girls' empowerment and their nutritional status in the context of low- and middle-income countries. Its goal is to help readers understand how and why empowerment is critical to adolescent girls' nutrition, and to identify empowerment-based

programming approaches that can be leveraged to reduce malnutrition and meet the nutritional needs of adolescent girls.

1.2 Objectives

This thesis addresses the following objectives:

1. To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs, and
2. To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs.

1.3 Thesis organization

This manuscript-based thesis is organized as follows:

Chapter 2 is a literature review of adolescent girls' empowerment and nutrition, focusing on the contribution of gender inequality to adolescent girls' malnutrition in LMICs and the theoretical and evidentiary roles that the process of empowerment can play to redress the gender-related drivers of malnutrition among adolescent girls in LMICs. This chapter provides the background and overarching rationale for the thesis.

Chapter 3 is composed of two manuscripts and addresses the first research objective stated above. The first manuscript is the protocol for the conduct of a Campbell systematic review of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs. It was published in Campbell Systematic Reviews in 2019.[17] The second manuscript is the systematic review report, which was submitted to *Campbell Systematic Reviews*.

Chapter 4 addresses the second research objective. It is the first of two manuscripts on the relationship between dimensions of adolescent girls' empowerment and their nutritional status in East Africa using Demographic and Health Survey (DHS) data to develop and test a series of exploratory structural equation models (ESEM). This first manuscript focuses on the specific case of married (currently partnered) adolescent girls aged 15 to 19 years. The article is published with *BMC Public Health*.[18]

Chapter 5 also addresses the second research objective. It presents the second ESEM manuscript for single (never married) adolescent girls aged 15 to 19 years using the same DHS datasets. This article is in peer review at *World Development*.

Chapter 6 is a discussion that brings together the results of the ESEM modelling and the systematic review work. It concludes the thesis with a discussion of the overall policy and research implications of the research and provides recommendations for future investigation.

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CHAPTER 2: Background

2.1 Chapter overview

As introduced in Chapter 1, this thesis focuses on the relationship between adolescent girls' empowerment and their nutritional status in low- and middle-income countries. Chapter two provides background information on: (1) adolescent girls' nutrition in LMICs, (2) the drivers of malnutrition among adolescent girls, with a focus on gender inequality and restrictive gender norms, (3) existing adolescent nutrition frameworks that incorporate the concept of empowerment, (4) the definition of empowerment and its related components as applied throughout this thesis, and (5) current knowledge gaps on the nutrition-empowerment relationship for adolescent girls.

2.2 Adolescent nutrition

Malnutrition is defined as deficiencies, excesses, or imbalances in a person's energy or nutrient intake, and comprises two broad categories – undernutrition and overnutrition. Undernutrition includes stunting (low height-for-age), wasting (low weight-for-height), underweight (low weight-for-age), and micronutrient deficiencies. Overnutrition refers to overweight, obesity, and diet-related non-communicable diseases (e.g., diabetes, heart disease, and stroke).

Globally, 13.4% of male adolescents (10 to 19 years) and 12.3% of female adolescents (10 to 19 years) are thin (defined as having a body mass index (BMI) less than two standard deviations (SD) below the median, according to WHO references for school-aged children and adolescents). This prevalence has declined just 0.5% in the last decade.[1] The prevalence of thinness among adolescents is highest in South Asia and East Africa, with rates as high as 26.7% in India, 17.2% in Afghanistan, 13.6% in Yemen, and 10.4% in Ethiopia.[2]

Over the last 10 years, adolescent overweight (including obesity) (BMI > 1 SD) has increased globally for both sexes (from 14.4% to 20.2% for boys and from 13.8% to 18.4% for girls).[1] The prevalence of overweight and obesity among adolescents is increasing rapidly in LMICs, and is projected to surpass the burden of underweight in this cohort by 2022.[3] A comprehensive study by the NCD Risk Factor Collaboration showed that, particularly in middle-income countries, a healthy BMI or height advantage (having a mean height higher than the WHO reference median) at age five can be reversed as children grow older, leading to them either losing their height advantage, worsening their height disadvantage, or experiencing an unhealthy BMI increase.[4]

Iron deficiency anemia, a condition in which blood lacks adequate healthy red blood cells, affects approximately 619 million adolescents globally and is the leading cause of disability adjusted life years (DALYs) in adolescents.[5] Adolescent girls are more likely to suffer from nutrient deficiencies because of their reproductive biology.[6] This becomes particularly problematic for women of reproductive age (15 to 49 years) where, in 2019, the global prevalence of anemia in non-pregnant and pregnant women was 30% and 36%, respectively. Iron deficiency anemia contributed to an estimated 22% of maternal deaths in 2019.[7] While the prevalence of moderate to severe anemia has declined since 2000, levels of mild anemia remain stable. The prevalence of anemia is highest among women of reproductive age in South Asia (non-pregnant = 50%, pregnant = 48%) and West and Central Africa (non-pregnant = 49%, pregnant = 52%).[8]

Linear growth is most heavily influenced by nutritional conditions during the first 1,000 days of life. Undernutrition early in life likely produces irreversible effects on linear growth and stunting may already be present at birth.[9] A recent study showed some improvement in trends related to the prevalence of height-for-age among adolescent girls in LMICs (from 30.6% in 2000 to 22.7% in 2015), with girls in middle-income countries experiencing the greatest improvements.[10]

The negative consequences of malnutrition during adolescence are not limited to reproductive health. Given the difficulty of achieving and maintaining weight loss, unhealthy weight gain in adolescence can have negative, long-term health repercussions into adulthood. Increased adiposity increases the risk of nutrition-related non-communicable diseases later in life.[11] Health and dietary habits adopted during adolescence are likely to continue in adulthood, making the former an optimal time to intervene. School performance, including grade attainment and attendance, suffers when adolescents are stunted, underweight, thin, or anemic.[12] There is an inverse association between iron deficiency anemia and cognitive function.[13] Economic productivity losses due to iron deficiency can be significant, largely attributable to iron-deficiency related cognitive deficits in children.[14]

Malnutrition among adolescent girls is particularly problematic because of its intergenerational effects.[15] Ten percent of total births occur among girls 15 to 19 years of age and 75% of adolescent pregnancies occur in LMICs.[16] Short stature increases the risk of intrapartum stillbirths, and being underweight contributes to poor fetal growth and higher risk of low birthweight.[10] Low maternal height is associated with stunting and wasting in children less than two years old.[10] Linear growth in the first two years of life is a strong predictor of adult intelligence.[17]

Research on adolescent girls' nutritional status has largely focused on its relationship to newborn and child health outcomes, and rarely on adolescent girls' nutritional status as a valuable outcome in itself.

Ensuring that adolescent girls achieve their full potential through improved health and nutrition is an important contributor to the development agenda in LMICs.[18] It is estimated that the economic consequences of malnutrition represent an annual loss of as much as 12 percent of gross domestic product in poor countries.[19]

2.3 Drivers of malnutrition

The drivers of malnutrition among adolescents are multi-factorial. Individual behaviours such as food choice, dietary intake, and physical activity are influenced by the food environment, which in turn is shaped by household and community dietary and activity patterns, economic development, urbanization, and food and agriculture systems.[20] Poverty and food insecurity can particularly affect young people because they have fewer resources to draw from or to withstand shocks brought on by crises, such as COVID-19.[21] For adolescent girls, *gender inequality and restrictive gender norms* play a specific role in their vulnerability to malnutrition, as elaborated below.

2.3.1 Gender equality and restrictive gender norms

Gender refers to "the characteristics of women, men, girls, and boys [and gender minorities] that are socially constructed. This includes norms, behaviours and roles associated with being a woman, man, girl, or boy, as well as relationships with others. As a social construct, gender varies from society to society and can change over time."[22] Gender is a social system that can be equitable but is most often patriarchal – ascribing power, resources, and status to men over women.[23] It is one of the most pervasive causes of health inequities for women and girls.[24] And while gender equality is widely recognized as a crucial social determinant of health, the integration of a gender lens in global health is uneven.[25]

Gender norms are "the often unspoken rules that govern attributes and behaviours that are valued and considered acceptable for men, women, and gender minorities."[23] Adolescence is a pivotal time when personal identity is shaped according to society's definitions of what is acceptable regarding men's, women's, and gender minorities' roles, behaviours, and entitlements. Gender norms and behaviours that reinforce inequality will permeate the rest of adolescents' lives, influencing their life course and the well-being of future generations.[26] They are already taking shape as early as age 10, and therefore central to the shaping of adolescents values and aspirations.[27] For girls, this often means a shrinking of future opportunities because their reproductive capabilities are prioritized over their own agency, education, and aspirations.[26] Girls' behaviour is often heavily policed by parents and guardians due to the perception that they should be protected from the risks their physical and social development may entail.[27] These

factors, in turn, may have serious repercussions for girls' nutritional status because of the strong influence of their home environment and the adults in their lives.[28–30] Adolescents depend heavily on adults to establish systems and structures to support them, such as their access to food, education, and health services, and yet they often lack a voice in terms of how these systems are shaped.

Heise and colleagues propose a conceptual framework of the gender system and health.[23] Among other things, the framework describes five gendered pathways through which gender inequality and norms contribute to health inequities, as follows:

Gender-related differences in exposures

Differential exposure to health risks can occur due to the varying roles and responsibilities ascribed to one's gender. Women's and girls' domestic responsibilities provide one example of how gender-related differences in exposure impact the nutritional status of adolescent girls. The collection of wood (for fuel) and water is predominantly carried out by women and girls in the household. For example, in Burkina Faso, 60% of girls gather wood or water, but only 35% of boys do.[31] The nutrition-related consequences are understudied compared to other health issues such as exposure to tropical diseases[32]; however, it is reasonable to conclude that this daily, physically demanding work requires a sufficient level of energy intake for adolescents to maintain their optimal growth trajectory.[33] It likely also increases their susceptibility to malaria, schistosomiasis, and soil- transmitted helminths – all of which contribute to anemia.[34,35]

Gendered health behaviours

Concepts related to what is acceptable behaviour for adolescent girls can also contribute to health inequities and malnutrition. Child marriage and pregnancy are strong examples of this pathway. Child marriage and adolescent pregnancy are the cause and consequence of gender inequality and restrictive gender norms that prioritize women's roles as wives, mothers, and household caretakers.[36] In 2021, 13.3 million children (10% of global estimates) were born to mothers under 20 years old.[37] The competition for nutrients between the still growing mother and the fetus restricts maternal growth and increases the risk of preterm delivery, low birthweight, and small-for-gestational age among neonates.[38] A study of the effects of child marriage and childbearing on women's nutritional status in India found that a higher proportion of women who were married before 18 years were thin (BMI < -2 SD) compared to women married at a later age.[39] Further, women whose first birth occurred before 18 years also had a higher probability of being thin. Similar patterns were found for early childbirth and anemia levels.

Eating patterns and behaviours are influenced by gender inequality and restrictive gender norms. Inequitable intrahousehold food allocation often disadvantages women and girls and is more likely in households that are poor or food insecure.[40–42] In Ethiopia, adolescent girls and boys were just as likely to live in a food insecure household, however, adolescent girls were more likely to be food insecure, even when comparing male-female siblings in the same household.[43] In rural areas of parts of South Asia, women and girls traditionally eat after male family members. In a sample of Hindu households in Nepal, adolescent girls and women were often served last at mealtimes, relegated to eating what was left over, if anything.[44] Individual food choice is shaped by gender roles and responsibilities, with adolescent girls having less autonomy and agency over food choices than boys.[45]

Other examples of gender-related behaviours that contribute to poor nutrition outcomes include unhealthy dieting behaviours and eating disorders to obtain often unrealistic body ideals, and limited participation in physical activity because it is not considered appropriate for adolescent girls compared to younger girls who are not restricted from physical activity.[46–48]

Gender impacts on accessing health care

Among the most prominent gender-related barriers to accessing health care for women and girls is their lack of financial autonomy and decision-making power. Consequently, they must rely on men, mothers-in-law, or other senior household members for permission to seek care or to cover transport and treatment costs.[49,50] The threat of violence travelling long distances to health clinics, along with fear of stigma, abuse, or mistreatment by healthcare workers, can discourage women and girls from seeking healthcare, especially reproductive health services.[51,52] Unmarried adolescent girls who may be pregnant can face particularly harsh treatment or consequences.[53,54] Time poverty due to the inequitable allocation of unpaid domestic work between women and men leaves women and girls with little discretionary time, preventing them from seeking healthcare.[55]

Gender-biased health systems

Nutrition services within health systems are often skewed to focus on pregnant and lactating women and children and neglect the nutritional needs of non-pregnant women and adolescent girls.[33] Laws and policies meant to protect adolescent girls can prevent them from accessing services. In Uganda, a law to prevent adolescent marriage and pregnancy was cited as one reason that adolescent girls delay health care to protect their partners from prosecution.[56] Fear of mistreatment by health workers is a common reason for women and adolescent girls to avoid health facilities.[57]

Gender-biased health research, institutions, and data collection

Sex- and gender-related differences in health, health information systems, data collection, and impact of interventions have long been neglected.[23] A review of adolescent health interventions, for example, found little research on and evidence concerning gender differences.[58] Sex disaggregation of data on adolescent dietary intake are also lacking.[45] While many adolescent nutrition interventions specifically target girls [59], those that do target both boys and girls often do not present their findings according to sex and/or gender.[60–62]

2.4 Adolescent nutrition frameworks

There are several conceptual frameworks related to adolescent nutrition, health, and well-being that acknowledge the role of gender systems. The recent Lancet Series on adolescent nutrition provides an updated conceptual framework for adolescent growth and nutrition (Figure 1).[20] The blue arrow illustrates that nutritional status in adolescence is influenced by nutrition earlier in life and impacts outcomes throughout adulthood and for the next generation. The food environment (grey arrow) influences the immediate drivers and outcomes of nutritional status – physical activity, cognitive and emotional growth, and food choice and dietary intake (the multicoloured ribbon). The framework highlights that adolescent have growing agency over their food and health choices (salmon arrow), and that this increased agency, in turn, influences their food environment. The multi-coloured arcs represent the broader socioeconomic systems that shape the food environment and adolescent agency, including gender systems.

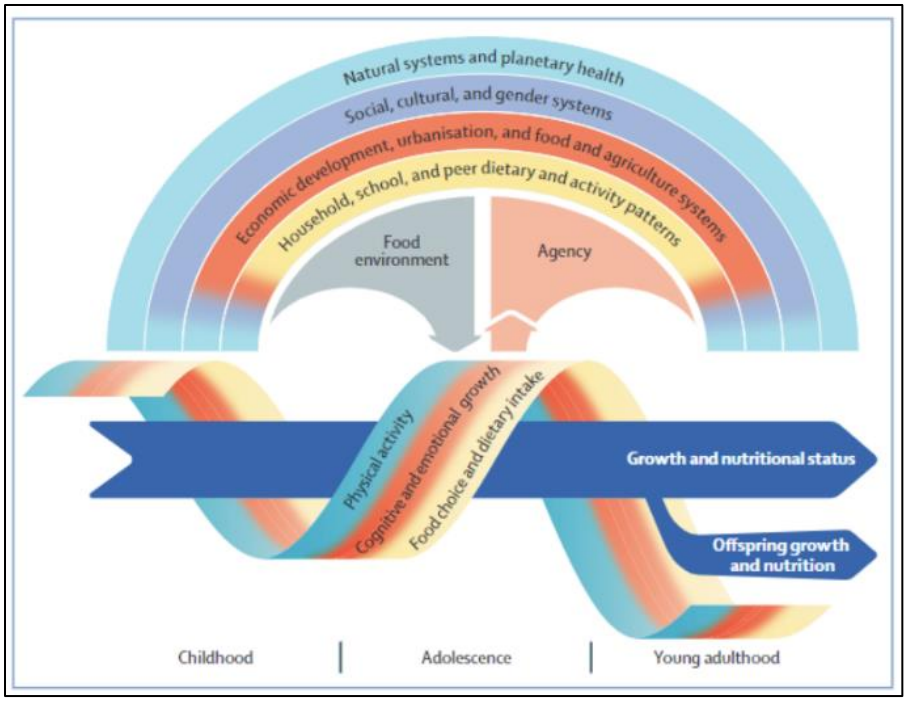


Figure 1. Lancet Series on Adolescent Nutrition conceptual framework for adolescent growth and development.[20] [1]

A framework proposed by Ross and colleagues defines adolescent well-being as "Adolescents have the support, confidence, and resources to thrive in contexts of secure and healthy relationships, realizing their full potential and rights."[63] They propose five interconnected domains to achieve well-being underpinned by gender, equity, and rights considerations:

1. **Good health and optimum nutrition**. Sub-domains are physical health and capacities; mental health and capacities; and optimal nutritional status and diet.
2. **Connectedness, positive values, and contribution to society**. Sub-domains are connectedness; valued and respected by others; responsible, caring, and respectful attitudes; interpersonal skills; socially, culturally, and civically active; and equipped to contribute to change and development.
3. **Safety and a supportive environment**. Sub-domains are emotional and physical safety; material conditions met; treated fairly with equitable opportunity; equal distribution of power, resources, rights; non-discrimination; privacy; and available enriching opportunities.
4. **Learning, competence, education, skills, and employability**. Sub-domains are commitment to and motivations for continual learning; education; resources, life skills, and competencies; acquisition of skills for future opportunities; employability; and confidence in abilities.

[1] Permission to reproduce this material is provided in Appendix A1.

5. **Agency and resilience**. Subdomains are agency and self-esteem; identify and comfort with self; sense of purpose; resilience to handle adversities; and fulfillment of potential.

The framework emphasizes the need for multisectoral approaches to adolescent well-being that address all five domains and its measurement.[64]

Similarly, a WHO framework describes proposed pathways from adolescent engagement to health and well-being (Figure 2).[65] The framework describes a process whereby meaningful adolescent engagement contributes to five interconnected pathways through which adolescents realize increased decision-making power and eventual improvement in health and well-being. The pathways are:

1. Improved adolescent-adult relationships
2. Increased self-efficacy and empowerment
3. Improved identity and sense of purpose
4. Increased social capital and peer connections
5. Improved competencies and confidence

The blue boxes at the bottom of the figure highlight the importance of an enabling environment for adolescent engagement and empowerment that includes supportive laws, policies, and structures, the institutionalization of engagement, and equitable policies and quality health care. The framework recognizes that unequal gender norms restrict adolescent girls' autonomy and agency, jeopardizing their health and well-being.

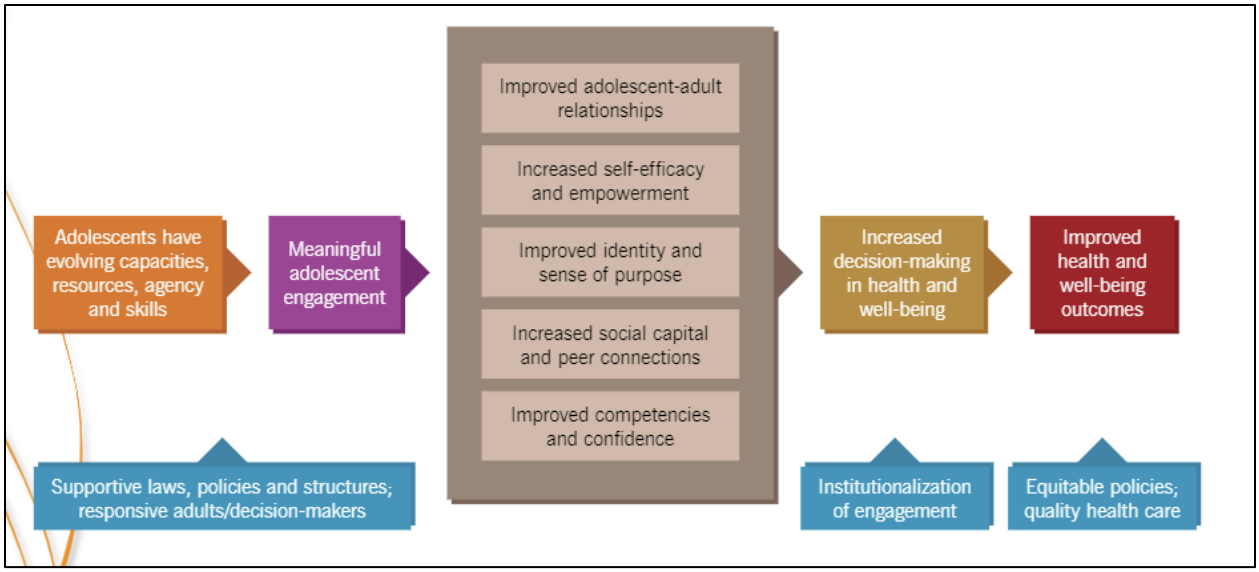


Figure 2. World Health Organization pathways from adolescent engagement to health and well-being. [65]

The WHO guideline on implementing actions for improving adolescent nutrition includes a framework of interventions and determinants of adolescent nutrition that emphasizes the need for a supportive enabling environment (via peer and interpersonal networks, families, and communities) to increase adolescent agency or capacity to access a nutritious diet, contribute to their health through positive behaviours, and access essential health services (Figure 3).[66] While not explicitly illustrated in the conceptual framework, the guideline recommends the implementation of gender-transformative programming that engages men and boys to redress restrictive and harmful gender norms that contribute to child marriage, coerced sex, and unintended pregnancy.

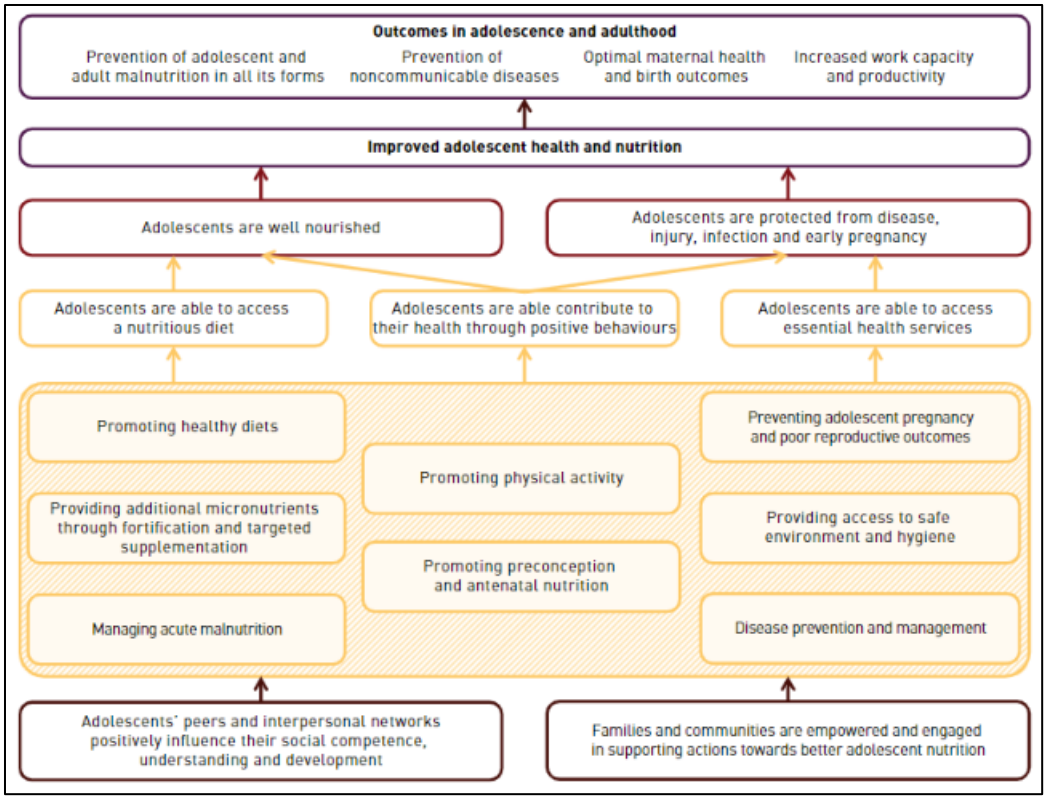


Figure 3. WHO framework of interventions and determinants of adolescent nutrition. [66]

A common theme in all these frameworks is the inclusion of the concept of empowerment, or its related components (e.g., agency), as critical to adolescents' health and well-being. The empowerment of women and girls is a global priority in the pursuit of gender equality and is enshrined in the UN Sustainable Development Goal (SDG5). SDG5 is viewed as critical to the achievement of many other SDGs, including SDG2 – to create a world free of hunger by 2030.[67] But what does empowerment mean and how does it apply to adolescents and their health, nutrition, and well-being?

2.4.1 Defining empowerment

Empowerment in the literature has numerous definitions,[68–72] but one that is commonly adopted in the context of women and girls' health and development is that of Kabeer. She describes empowerment as "the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them."[73] Kabeer's definition reflects the idea that empowerment is a process – moving from a position of disempowerment, where choice and opportunity is limited, to one where an individual can set and achieve their desired goals. In a similar vein, the *capability approach*, pioneered by Sen and expanded on from a feminist and human rights perspective by Nussbaum, argues that, for a

person to achieve their highest potential, their life must include several central capabilities that are universal and important for everyone, regardless of their sex, age, ethnicity, socioeconomic status, and other determinants of health.[74,75] A person's capability reflects their potential to live the life that they want. Overall, the literature on empowerment reflects three interrelated and interdependent components of empowerment: *agency*, *opportunity structure*, and *achievements*. The following sections define each concept and how it relates to adolescent empowerment and nutrition.

Agency

Central to the concept of empowerment is *agency*, or the "ability to define one's goals and act upon them."[73] This can be reflected in a person's decision-making power, but it also encompasses their intrinsic beliefs related to self-efficacy and self-confidence – i.e., whether an individual believes that she/he can produce her/his desired outcomes through individual action. Agency can also be fostered and exercised at a collective level, such as through political or social movements, and is increasingly important in an interconnected world.[76]

Adolescent agency is influenced by several factors, including their sense of self-efficacy, self-esteem, experiences of connectedness, freedom from gender-based violence and discrimination, bodily autonomy, and feelings of import or significance to the people and places in their lives.[77] It shapes their resilience to prevent, adapt to, and weather adversity, and is fostered by the availability of safe spaces to develop and express their self-identity.[78,79]

The Gender and Adolescence Global Evidence (GAGE) "3 Cs Conceptual Framework" [80] (Figure 4) identifies voice and agency as one of six priority capability outcomes. Similarly, Vidyarthi et al. highlight strengthening adolescents' individual and collective agency and resilience as foundational to adolescent well-being, including their health and nutrition.[78] They review several evidence-based programming interventions, such as increasing adolescents' awareness of their rights and harmful social norms and behaviours, promoting intergenerational dialogue to change harmful social norms and engage men and boys as champions of gender equality, and providing adolescents with opportunities to design and implement solutions that address their needs and promote positive change in their communities. In the context of nutrition, this includes changing norms around inequitable intrahousehold food allocation and the practices of child marriage and adolescent pregnancy.

The relationship between agency and health is bidirectional; greater agency can lead to improved health, and vice versa.[78] In Ethiopia, adolescent girls' agency was positively associated with positive descriptive and injunctive nutrition norms.[81] In other words, more gender equitable social norms related to nutrition (e.g., married adolescent girls eat meals at the same time as their husbands) were associated

with higher levels of girls' agency. Neufeld et al. explored the way that adolescent dietary intake and agency over food choice is impacted by different stages of adolescent development, the sociocultural context, and the food environment.[45] They particularly highlight the importance of adolescents' burgeoning agency and autonomy as key contributors to their food choices – for better or for worse. Greater autonomy may lead to the increased consumption of energy-dense but nutrient-poor foods in modern and mixed food environments, such as urban and peri-urban centres in LMICs. They highlight the importance of designing programmes to address specific life stages, such as early (10-14 years) vs. late (14-19 years) adolescence, and contextual features through processes that engage adolescents as active partners.

Opportunity structure

Alsop and Heinsohn describe the importance of a conducive *opportunity structure* in which decisions are made and acted upon as central to the empowerment process.[69] They define opportunity structure as "the formal and informal contexts within which actors operate." Formal contexts include institutions, policies, and legal frameworks that either do or do not protect, promote, and fulfill adolescents' rights. Strategies to create a supportive opportunity structure for adolescent empowerment in formal contexts include strengthening adolescent-friendly school systems and services, advocating for supportive legislative and policy frameworks that guarantee adolescent rights (such as sexual and reproductive health and rights, and forbidding child marriage), increasing budget allocations for adolescent responsive laws, policies, and programmes, and strengthening accountability mechanisms that meaningfully and equitably engage adolescents.[78,80] Organizations delivering adolescent programming should also consider how their own organizational ideologies and values can either facilitate or impede adolescent empowerment.[79]

Informal contexts that contribute to a supportive opportunity structure for adolescent empowerment are largely driven by social (including gender) norms. Working with adolescents' duty bearers (i.e., parents/guardians, community leaders/members, traditional/religious leaders) and peers to raise awareness and support for adolescents' rights (including gender equality) and to redress restrictive gender norms is crucial to creating a supportive opportunity structure for adolescent agency and empowerment. Engaging men and boys is especially critical for long-term, structural change.[79,82] Programmes that facilitate alliances between girls and boys or men and women have been found to produce significant positive changes in gender and health, while programmes that ignore restrictive structural characteristics and gender norms were less successful in achieving their gender and health-related objectives.[83] Positive social and community influences also shape adolescent choice and behaviour related to their diet and nutrition.[21]

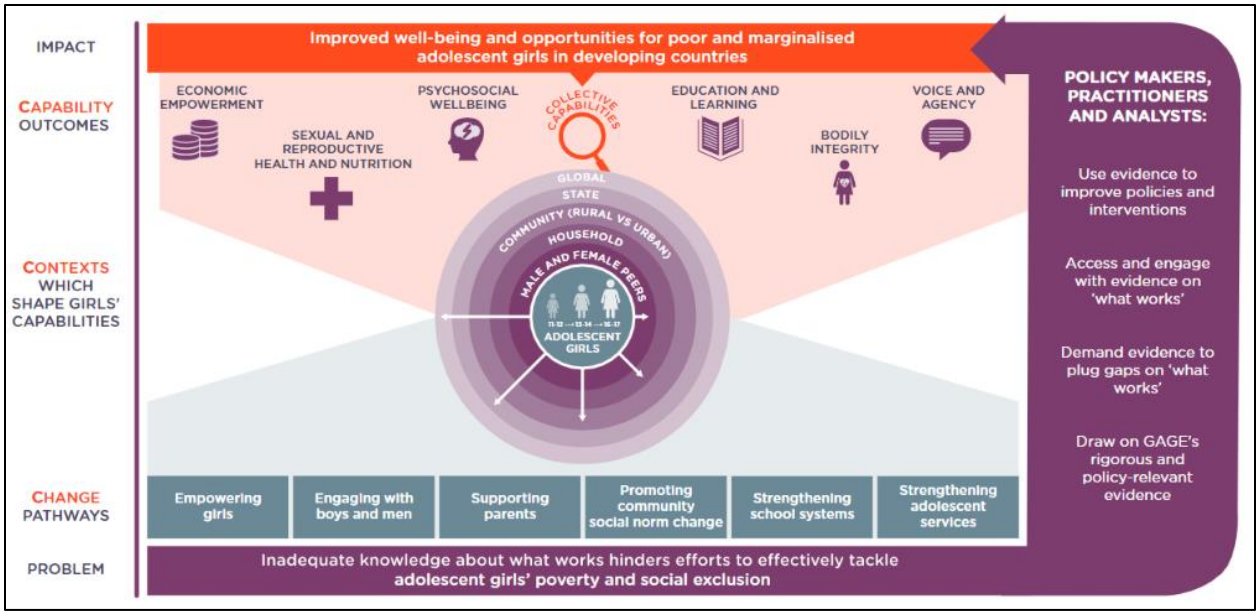


Figure 4. Gender and Adolescent Global Evidence (GAGE) 3 Cs conceptual framework. [80]

Achievements

The final component, *achievements*, refers to the realization of adolescents' goals, as they define them. Better methodologies to measure achievements in a way that accurately capture adolescent's goals and intentions are needed.[84] Recent studies of the effects of nutrition programming for adolescent girls that include empowerment strategies are mixed. Some examples are provided below.

Example 1

A formative evaluation of a 'girl-powered' nutrition program in four LMICs embodied many of the principles of adolescent empowerment detailed above.[85] The study found that meaningful adolescent engagement in the co-design of the intervention led to greater uptake. Engaging gatekeepers and duty bearers, especially men and boys, was also critical, given their role in household decision-making. The evaluation provided examples of where girls' improved confidence and skills led them to engage with their close social and family circles in nutrition advocacy. However, it also pointed out that the structural challenges of poverty and engrained gender inequitable norms can prevent long-term success.

Example 2

Hewett and colleagues undertook a comprehensive adolescent-girl-focused empowerment programme in Zambia with a nutrition component that was evaluated using a cluster-randomized design. [86] When a

tailored nutrition education intervention, delivered through weekly mentor-led girls' groups, was added to the girls' empowerment programme in one study arm, they found no statistically significant difference in girls' nutritional knowledge, likelihood of being underweight, stunted, or anemic, compared to girls' who received the empowerment programme but not the nutrition education intervention. They conclude that the low levels of educational experience and literacy among the study population and the lack of an opportunity structure component may have contributed to the lack of impact.

Example 3

Muturi and colleagues examined the relationship between youth empowerment and obesity prevention behaviours among American adolescents living in low-income communities. Empowered youth were more likely to report greater self-efficacy for healthy eating, healthy food choice, and physical activity. They also reported more positive perceptions of food availability and community support for physical activity, and fewer perceived barriers to healthy eating and physical activity.[87]

2.4.2 Implementation

There is also evidence that implementation approaches are understudied in adolescent girls' programming. A systematic review of implementation approaches applied to adolescent girls' programmes in LMICs found that few studies assess implementation science questions overall. Their analysis identified positive associations between multi-component programmes (vs. single component) and longer program exposure (vs. shorter exposure) with more favourable outcomes for girls, but limited evidence of the value of multi-level interventions (i.e., programs that reach not just the beneficiary but also other actors who directly or indirectly affect their lives and well-being) compared to interventions that only target the adolescent girl.[88]

2.5 What we do not know

The relationship between adult women's empowerment and maternal and child nutrition outcomes is well established.[89–92] This evidence base demonstrates that different dimensions of empowerment (e.g., household decision-making, financial autonomy, freedom of movement, etc.) are associated with different maternal and child health and nutrition outcomes. However, the evidence base for adolescent empowerment and nutrition is sparser. The causal pathways through which empowerment contributes to improved nutrition for adolescent girls has yet to be fully understood and articulated. Given the unique challenges and opportunities presented by adolescence for nutritional and developmental gains, understanding the nutrition-empowerment relationship is imperative. In the following chapters, this thesis will explore some of these key evidence gaps.

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CHAPTER 3: The effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs

Chapter overview

Chapter 3 addresses the first research objective: To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs. It is composed of two sections. The first section (Section 3.1) is the protocol for the conduct of a Campbell Systematic Review of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs and the second section (Section 3.2) is the systematic review report.

Before this thesis was undertaken, there had been no comprehensive review of nutrition interventions for adolescent girls in LMICs that incorporate an empowerment-based approach. As such, the objective of this chapter was to systematically search existing peer-reviewed and grey literature to identify, describe, and synthesize the results of randomized controlled trials and non-randomized studies that assess the effectiveness of empowerment-based nutrition interventions to improve adolescent girls' nutritional status in LMICs. Further, the systematic review examined the role of implementation and contextual factors in the success or failure of these interventions. To guide the systematic review, a logic model that depicted the theorized causal chain linking empowerment-based nutrition interventions to improved nutritional status was developed following a review of existing conceptual models for adolescent nutrition and empowerment. The systematic review findings were then used to update the logic model based on the review's findings.

3.1 PROTOCOL: The effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries

This section presents a manuscript that describes the protocol for a mixed-methods systematic review of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries. A mixed method segregated research synthesis (MMRS) design was selected because of its effectiveness in studying interventions that consist of multiple components; allowing reviewers to better understand how the different components are related and interact with each other. An exhaustive, systematic search strategy was employed to identify eligible studies. The review's design, including inclusion criteria, data extraction, and synthesis methods, were informed by the development of a theoretically informed logic model of the causal linkages between empowerment-based nutrition interventions and adolescent girls' nutritional status. The logic model underpinning the review is a unique contribution to the published literature, providing a clear definition of the main components of an empowerment-based nutrition intervention that can be used to design and evaluate interventions for adolescent girls in LMICs.

The findings of the systematic review are presented in Section 3.2.

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Authors' roles and contributions

AYR, GW, VW conceived the study. BS designed the search strategy. AYR drafted the protocol, which was revised by all authors. All authors approved the version of the manuscript submitted for publication.

Related thesis appendices

Appendix A2: Published manuscripts. The PDF of the published manuscript is presented in Appendix A2.

PROTOCOL: The effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries

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Background

The problem, condition, or issue

Adolescents (10 to 19 years) currently represent the largest global generation of young people in our collective history.[1] The regions of Africa, Asia, Latin America, and the Caribbean are the home of 1.1 billion young persons.[2] In sub-Saharan Africa, people below the age of 25 make up 62% of the population, with only marginal declines predicted through 2050.[3] The working age population (25 to 64 years) in sub-Saharan Africa, Oceania, and parts of Asia, Latin America, and the Caribbean is growing faster than all other age.[3] Ensuring the health and well-being of adolescents who will fill the ranks of the world's working age population will help to propel global economic growth and development.[4]

Adolescence is a period of significant physiological change that includes marked skeletal growth, increased bone mass, and fundamental neurological development.[4,5] Proper nutrition during adolescence is crucial for optimal growth and development and helps to prepare adolescents for adulthood. However, many adolescents face challenges in achieving optimal dietary intake, especially in low- and middle-income countries (LMICs) where the majority of adolescents reside.[6] Iron-deficiency anemia affects 430.7 million (24%) adolescents, with 77% of adolescents living with anaemia in multi-burden countries where communicable, maternal, and nutritional conditions contribute to 2,500 disability adjusted life-years (DALYs) or more per 100,000 adolescents.[7] The prevalence of anaemia is consistently higher for females than males, and is more than 50% for females in Bhutan, Yemen, India, and Burkina Faso in 2016.[7] Mean BMI (body mass index) and the prevalence of obesity are also rising among children and adolescents globally. The percentage of adolescents who are overweight or obese was 324.1 million in 2016—an increase of 176.9 million from 1990.[7] The median prevalence of overweight and obesity among girls is highest in the Eastern Mediterranean region (28%), followed by the Western Pacific (25%), the Americas (25%), and Europe (21%).[8] Yet more children and adolescents are moderately or severely underweight globally, with the largest burden of underweight found in South Asia and central, east and west Africa.[9]

The social, economic, and cultural conditions in which an adolescent matures can significantly shape their health and development, including their nutrition. The social determinants of health are the conditions in which people are born, grow, develop, live, work, and age.[10] Social inequities, particularly those related to poverty and gender, can heavily influence adolescent health and well-being.[4] Adolescence is a time when gender roles and norms become more heavily engrained, affecting how adolescents interact with and experience the world. The gendered experience of adolescence can vary depending on the context, as Kabeer writes: "In many LMICs, the gendered norms embedded in local structures of patriarchy come

into play in heightened ways during adolescence, restricting the agency, opportunities, aspirations and social networks of young girls to a far greater extent than boys."[11] Where considerable gender inequities exist, women and girls are more likely to suffer from nutritional deficiencies than men and boys.[12] Gender inequities can limit access to an adequate diet and lead to early marriage and high fertility rates, putting adolescent girls at greater risk of nutrient deficiencies as well as poor pregnancy and birth outcomes.[8,13] Numerous studies have identified a significant association between women's empowerment and women's and children's nutritional status.[14–20]

The intervention

The empowerment of women and girls has been identified as way of improving the nutrition sensitivity of interventions, in addition to achieving scale and increased coverage of at-risk households and individuals.[21] There is growing interest in assessing the impact of empowerment interventions on women's empowerment as well as its instrumental value in improving development outcomes, including women's and children's health and nutrition. The objective of this is review is to build on the existing literature base to examine the effects of integrating women's empowerment strategies in nutrition interventions to improve the nutritional status of adolescent girls in low- and middle-income countries.

Defining women's empowerment and its related components

There are various definitions of women's empowerment, illustrating the complexity of the construct.[22–28] A commonly used definition is that of Naila Kabeer. She defines empowerment as "the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them."[29] Kabeer identifies three interdependent components to women's empowerment. The first is agency, or "the ability to define one's goals and act upon them."[29] Alsop and Heinsohn (2005) define agency as "the ability to make meaningful choices." Similarly, A. Sen describes agency as "what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important."[30] Central to these definitions is (a) the availability of alternatives from which to choose, (b) the individual is aware of the alternatives available to them and (c) the individual desires to make a choice.[22,29] Agency is often described in terms of decision-making power, but it can also reflect an ability to bargain, negotiate, influence, resist, or manipulate.[24]

Kabeer (2001) identifies the second component of empowerment, resources, as a precondition for the ability to exercise choice (agency). Resources can be material, human or social. Alsop and Heinsohn (2005) refer to this component as opportunity structure, or "the formal and informal contexts within which actors operate." We will use the term "opportunity structure" to represent this second component for the purposes of this review. A supportive opportunity structure will enable an individual to make their

choices a reality. For example, an adolescent girl may desire to stay in school until graduation, but she may be prevented from doing so if her father prefers her to be married.

The final component is achievements. Agency and opportunity structure interact to result in the achievement of an individual's desired outcomes. A. Sen (1985b) refers to this interaction as capabilities, or the potential that people have for living the lives they want. Notably, chosen actions that lead to undesired outcomes do not signify a high degree of empowerment. For example, the decision to participate in a microcredit programme may increase a woman's access to financial resources, but if her husband controls how those resources are spent, the desired outcome of financial autonomy would not be achieved.

Empowerment can take place in different dimensions of women's lives. A high degree of empowerment in one area does not automatically translate into empowerment in other areas. For instance, an adolescent girl may be able to attend school (an indicator of social empowerment) but she may be denied the right to access health care without her guardian's permission (an indicator of household or intrafamilial empowerment). There are six conceptual definitions of empowerment commonly used in the literature.[26,31] Below we briefly describe each and provide indicators at the individual level.

- *Economic*: Access and claims to material resources. Examples of individual-level indicators include control over one's income, access to the labour market, having a bank account, etc.
- *Political*: Inclusion in political processes and the ability to self-organise. Example indicators are the ability to organise and participate in a women's advocacy group or women's membership on a local council.
- *Legal*: Women's rights as codified in law. Example indicators are the ability to own property and the right to vote.
- *Socio-cultural*: The type and quality of relationships with other people and groups outside of the household, often highly influenced by society's gender norms. Examples include women's freedom of movement and society's commitment to girls' education.
- *Intrafamilial*: The social hierarchy and dynamics within the household. Examples are women's role in household decision-making or their sexual autonomy.
- *Psychological*: An individual's belief that they can achieve their goals. An example is an individual's perception of their own self-efficacy. This dimension is closely related to the concept of agency.

The gender equality challenges and the relevance of different empowerment dimensions will vary by context. For example, sociocultural norms in South Asia can restrict women's ability to leave home

without a male relative or chaperone. In sub-Saharan Africa, migrant labour among men is common, giving women greater levels of independence, if not actual autonomy.

Operationalizing women's empowerment

The operationalization of women's empowerment in health and development programmes in recent years has largely focused on improving access to resources, assets, and services. Interventions that have been assessed include women's self-help groups (often with an economic focus),[11,32–36], cash transfer programmes,[37–41] microcredit programmes,[34,42–46] agriculture programmes, [41,47] and programmes to strengthen inheritance and property rights.[48–50]

Shankar, Sundar, and Smith (2019) have written about the gap in focusing specifically on agency-based interventions, that include "designing spaces that allow individuals to self-define their goals in life areas such as work, relationships, sexuality, spirituality, or financial security." Similarly, Cornwall has highlighted the neglect of building "critical consciousness" as part of women's empowerment interventions in favour of a focus on resources.[51] We will build on their work by assessing the effectiveness of nutrition interventions that include activities to foster agency as well as creating a supportive opportunity structure (including access to resources) as a way to empower adolescent girls and improve their nutritional status. Further, we will summarise the contextual and implementation factors that contribute to the success or failure of these interventions.

Empowerment-based nutrition interventions

This review will summarise the evidence concerning the effectiveness of empowerment-based nutrition interventions for adolescent girls in low- and middle-income countries. In other words, we will assess the effectives of nutrition interventions that include activities to (a) foster adolescent girls' agency and (b) create a supportive opportunity structure for adolescent girls' empowerment. For the purposes of this review, we define nutrition interventions as interventions intended to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation.[52] Examples of eligible nutrition interventions are micronutrient supplementation (iron, folic acid, vitamins A, D, etc.), food supplementation programmes (e.g., school feeding), and nutrition education or counselling.

To be empowerment-based, the intervention must include activities to support adolescent girls' agency and activities to create a supportive opportunity structure for adolescent girls' empowerment. An intervention that fosters agency will include activities designed to increase adolescent girls' motivations and abilities to make informed decisions by providing spaces for self-reflection and identification of

important life areas.[53] Such interventions enable adolescent girls' active and meaningful participation in decision-making, instil a sense of self-efficacy, and increase self-esteem and motivation to make a positive change in pursuit of strategic life goals. Examples of activities that foster agency are life skills training programmes, mentorship programmes, counselling programmes, and other programmes that create "safe spaces" for adolescent girls or equip adolescent girls to make informed strategic life decisions. Interventions can be delivered one-on-one or in a group setting and can take place in a variety of settings include at home, at school and in the community.

The intervention must also include activities to build a supportive opportunity structure. Such activities aim to alter the constraining political, economic, socio-cultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency.[22,26] This includes access to and control over resources. The type of activities that are undertaken to create a supportive opportunity structure will vary by context, thus we cannot provide an exhaustive list. Instead, we have attempted to categorize activities by type according to the dimension of empowerment they seek to redress. They are:

- Economic: Economic activities aim to increase adolescent girls' access to and control over financial and material resources. These include microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.
- Socio-cultural: Socio-cultural activities aim to redress discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intrahousehold food discrimination, and programmes to support adolescent girls' completion of secondary education.
- Legal: Legal activities aim to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights. This can include adolescent girls' rights to education, family planning, employment or inheritance.

Table 1 provides examples of how the three different intervention components can combine to create an eligible intervention study. Each intervention must have as its main activity a nutrition intervention aimed to improve dietary intake among adolescent girls. In addition, an eligible intervention must include agency-related activities and opportunity structure activities.

An example of a primary study that may be included in this review is the Adolescent Girls Empowerment Programme in Zambia.[54] The 2-year, multi-arm cluster randomised controlled trial assessed the impact

of an "asset-building framework" intervention on the empowerment and health status of girls aged 10–19 years. The intervention provided nutrition education using participatory methods (nutrition-specific component), alongside a weekly mentor-led girls groups meeting covering health, life skills and financial education (agency component), and a health voucher and savings account programme (opportunity structure component). The study assessed a series of anthropometric measures and anaemia status, as well as empowerment outcomes between the intervention and control groups.

Table 1. Examples of eligible intervention studies that include all three intervention components.

Study	Nutrition		Agency		Opportunity Structure		
	Promoting a healthy diet	Micronutrient supplementation or fortification	Individual	Group	Economic	Sociocultural	Legal
Study 1	X		X		X		
Study 2		X		X	X	X	
Study 3	X	X		X			X

How the intervention might work

We hypothesise that including empowerment-related activities in a nutrition intervention will mediate the impact of underlying gender inequities that contribute to poorer health outcomes for adolescent girls and will result in greater nutritional gains compared with programmes that do not promote women's empowerment.

Our logic model is presented in Appendix A. The logic model depicts the causal pathways from the implementation of an empowerment-based nutrition intervention to improved nutrition outcomes for adolescent girls. The development of the logic model was informed by a review of existing models and conceptual frameworks on nutrition [36,52,55–57] and women's empowerment.[22,24,26,28,36,41,58]

The model begins with the proposed three elements of an empowerment-based nutrition intervention:

1. Activities to improve dietary intake
2. Activities to foster agency
3. Activities to build a supportive opportunity structure

In the short term, the elements are hypothesised to lead to an expansion in an adolescent girls' awareness of the choices available to her to improve her nutritional status, and to increase her motivation to act. The nutrition-related activities will improve her awareness, knowledge, and skills for the adoption of a healthy diet and positive health behaviours. The agency-related activities complement the nutrition-related knowledge she has acquired to increase her awareness and motivation to make an informed choice to

improve her health and nutrition. A supportive opportunity structure will enable her to move toward action based on her choices. For example, a school-based micronutrient supplementation programme for adolescent girls that includes a peer support programme to build girls' nutrition-related knowledge and self-confidence (agency) and a sensitisation programme for parents and teachers to the importance of supplementation for adolescent girls (opportunity structure) will increase a girl's knowledge of the importance of supplementation for her health and well-being, increase her motivation to participate in the supplementation programme, and create an enabling environment that will provide the necessary resources and supports for her to participate in the programme.

In the intermediate term, the intervention is expected to empower adolescent girls by increasing their decision-making power, improving their access to and control over resources (human, capital, social), and contribute to the protection and promotion of their human rights, such as the right to health care, education, freedom of movement, freedom from violence so forth. Returning to our illustrative example, an adolescent girl will have more decision-making power because she has acquired the information that she needs to make an informed decision, she has the confidence to make a decision, and she has the support from parents and teachers to enable her decision-making. Her access to resources is also theoretically improved with the support of the adults in her life. Finally, the sensitisation of parents and teachers should help to prevent any potential restrictions on her rights that may impede her ability to participate in the programme.

Moving down the results chain, the empowerment-related outcomes are hypothesised to feed into improved health and nutrition behaviours, improved access to a nutritious diet, and improved access to essential health services. In the case of our example, an intermediate outcome would be adolescent girls' taking micronutrient supplements consistently because they have decided it is important to them, and their environment supports them to do so. And in the longer term, the intervention would lead to improved dietary intake and improved nutritional status.

The exact causal pathways will vary depending on the intervention design which should be informed by the context and the particular gender-related barriers present. While we have focused this systematic review on interventions to improve dietary intake, the logic model includes pathways to improved nutritional status via improved access to essential health services for the prevention of diseases that contribute to malnutrition (e.g., malaria) and the prevention of early pregnancy—a significant contributor to malnutrition among adolescent girls.[55]

Promoting women's empowerment can also potentially lead to adverse effects. For example, adolescent girls, empowered to choose their own diets, may opt to consume low-nutrient foods, such as sugar-

sweetened beverages.[8] There may also be backlash within the household or community in response to adolescent girls' attempts to assert increased autonomy, which may be perceived as threatening traditional power structures. Capturing the adverse effects of the intervention is a critical component to be explored that will assist in intervention design that maximises benefits and minimises harms.

Underpinning the logic model are the individual-level, household/community-level, and macro-level factors that can moderate the expected outcomes along the causal pathway. At the individual level, socially stratifying factors that contribute to health inequities have the potential to place additional barriers to proper nutrition for adolescent girls and need to be considered in intervention design and evaluation. The PROGRESS-Plus framework [59] is a useful pneumonic summarising these factors: Place of residence, Race/ethnicity/culture/language, Occupation, Gender/sex, Religion, Education, Socioeconomic status, and Social capital. The "Plus" stands for other personal characteristics (e.g., age or disability), features of relationships (e.g., children of parents who smoke), and time-dependent relationships (e.g., recently out of hospital) that can make an individual more vulnerable to poor health. Moving up one level, household and community characteristics can affect intervention design and results as well. Things to consider include household food security and water and sanitation facilities, the availability of health services in the community, women's representation in community leadership or other governing bodies, and other community gender norms, such as son preference. Finally, consideration of the macro-level context includes such things as the national or regional food environment and food security, national gender-related laws, policies, and institutional practices such women's rights to land ownership, and women's participation in the economy. The exact strategies necessary to foster agency and opportunity structure are highly context-specific and point to the importance of understanding not only how women's empowerment affects nutrition outcomes, but also how these contextual factors influence intervention effectiveness.

A final element to consider are the implementation factors regarding the intervention itself.[60] These include the intervention setting and delivery platform (e.g., school, health facility, community, etc.), the intervention provider (e.g., teacher, community leader, facility-based health worker, community health worker, etc.), how participants were recruited, participant retention strategies and attrition rates, the reach and dose of the intervention, fidelity to intervention design, and the adaptability of the intervention to the local context and circumstances.

Why it is important to do this review

There is a rapidly expanding body of literature on women's empowerment and health, including nutrition. Below we summarise existing reviews of interventions related to women's empowerment and nutrition in

low- and middle-income countries. Our systematic review will contribute to the existing evidence-base by: (a) focusing on the role of empowerment in adolescent girls' nutrition (an understudied population), (b) attempting to separate out the role of agency-related and opportunity structure-related activities in the empowerment process, and (c) systematically reviewing and synthesising the evidence on the contextual and implementation factors that may help to explain the success or failure of empowerment-based nutrition interventions.

Reviews

Van den Bold, Quisumbing, and Gillespie (2015) conducted a review of nutrition-sensitive structural interventions (cash transfer, agriculture, and microcredit programmes) to assess their impact on women's empowerment and infant and child nutrition, and found that, despite the existence of considerable evidence depicting the associations between women's empowerment and nutritional status, more research is needed to understand the pathways that connect the two concepts. The review did not examine outcomes for adolescent girls. Similarly, Taukobong et al. (2016) reviewed the literature across six sectors, including nutrition, to assess whether addressing gender inequalities and empowering women and girls improves health and development outcomes. They identified common gender equality and women's empowerment variables that repeatedly emerged as significant predictors of sector outcomes, including control over income, decision-making power, and education, but also identified the need for more research into mechanisms through which gendered interventions might work. The review did not examine outcomes for adolescent girls.

Brody et al. (2015) conducted a systematic review of economic self-help group programmes for improving women's empowerment. They concluded that self-help groups have positive effects on women's economic, social, and political empowerment. Qualitative findings indicated that the poorest women were less likely to participate due to time constraints and fears of racial or caste discrimination. The review did not assess the impact of economic self-help groups on health or nutrition outcomes for women.

Kumar et al. (2018) conducted a review of women's group-based programmes and nutritional change in South Asia. They mapped interventions to four conceptual pathways (income, agriculture, health and nutrition behaviour change, and rights) from women's groups to improved nutritional status among women and children. They found the strongest evidence linking the behavior change pathways to improved nutritional status, but also noted a number of challenges in assessing the evidence based including the lack of rigorous studies, difficulties in disentangling the effects of group-based activities with other aspects of the intervention, a paucity of studies targeting nutritionally vulnerable age groups,

and programmes with insufficient reach and duration. They recommend that implementers and evaluators identify a priori which change pathways they anticipate to activate and measure processes and impacts accordingly. The review did not examine outcomes for adolescent girls.

Brandstetter, Rüter, Curbach, and Loss (2015) conducted a systematic review of the various ways of applying the empowerment concept to healthy nutrition in health promotion. The included eight studies that were all based in high-income countries. They found diversity in the way the concept of empowerment was operationalized, in the integration of other theoretical frameworks (e.g., socio-cognitive theory), and reporting in the methods of operationalizing and measuring empowerment.[61]

The WHO Guideline, "Implementing effective actions for improving adolescent nutrition" [52] summarises the global evidence for addressing malnutrition in adolescents. The guideline identifies implementing interventions to empower adolescent girls may prevent early marriage and pregnancy, reduce sexual coercion, and notes that community stakeholders (including teachers and health workers) need to support the empowerment of adolescents to adopt and maintain optimal nutrition and health practices. The guideline further identifies as a research gap the assessment of impact of interventions and policies on autonomy, positive development, empowerment, and engagement of adolescents.

Recent systematic reviews of adolescent nutrition interventions [13,62,63] have shed valuable light on the effectiveness of nutrition interventions in improving adolescent health, but they have not specifically assessed the role of empowerment in adolescent health and nutrition.

Protocols

Vollmer et al. (2017) have published a protocol for a systematic review of the effect of women's economic empowerment on children's health and education.

Objectives

The primary objective of the review is to answer the following:

1. Does promoting women's empowerment within nutrition interventions improve the nutritional status of adolescent girls in low- and middle-income countries?
2. What are the factors influencing the success or failure of these interventions?

The secondary objective is to answer the following:

3. What are the underlying empowerment-related programme theories that influence intervention design? How is empowerment defined, operationalized, and measured?

4. What is the effect of promoting women's empowerment in nutrition sector interventions on adolescent girls' empowerment-related outcomes?
5. What are the potential adverse effects of promoting women's empowerment in nutrition sector interventions on adolescent girls' health and well-being?

Methodology

This review will apply a segregated mixed methods research synthesis design (MMRS). An MMRS combines qualitative, quantitative, and mix-method primary-level studies and applies a mixed methods approach to synthesise and integrate the studies' results.[64] This design is more appropriate for the study of interventions that consist of multiple components as it helps to better understand how the different components are related and interact with each other.[64]

Through a comprehensive literature search, we will identify relevant literature with qualitative and quantitative study designs that will be segregated at the screening phase. Qualitative and quantitative studies will be analysed and synthesised separately, while the implications for practice, policy, and research that will form the discussion and conclusion sections of the review will draw on both the qualitative and quantitative syntheses.

Criteria for including and excluding studies

Types of study designs

The following study designs will be included to answer Research Question 1 (effectiveness assessment):

- Randomised Controlled Trials (RCTs)
- Cluster Randomised Controlled Trials (cRCT)
- Controlled before and after studies (CBAs)
- (Controlled) interrupted time series (CITS, ITS)
- Propensity score matching (PSM) on baseline covariates
- Regression discontinuity design (RDD)
- Difference in difference using regression techniques (DID)
- Interventions with a synthetic control group
- Other quasi-experimental designs with at least one comparison group

Studies without an observable comparator or credible means for controlling for selection bias will be excluded.

To answer Research Question 2, we will include companion quantitative and qualitative studies that assess the contextual and implementation factors influencing the effectiveness of the studies screened into the effectiveness assessment (Research Question 1).

We will include qualitative studies that explore the perspectives of intervention participants (adolescent girls), providers (those who delivered the intervention), or administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors contributing to intervention success or failure using focus groups, in-depth interviews, or participant observation. Eligible qualitative study designs include case studies, ethnographic research, grounded theory, and other thematic approaches to qualitative data analysis. Qualitative studies that do not report a clear methods and results section will be excluded. This includes opinion pieces and editorials. Eligible quantitative study designs that assess the implementation of included studies are process evaluations, surveys of intervention participants, providers, administrators, and other programme-related documents such as monitoring and evaluation reports.

Studies that apply a mixed methods design will be included where the qualitative and quantitative study components are reported separately.

Types of participants

The review target population is adolescent girls (10 to 19 years) residing in low- and middle-income countries, regardless of health status.

The classification of countries as low- or middle-income will be based on the World Bank income groups as defined at the time the studies were conducted. Studies undertaken in high-income countries will be excluded.

Types of interventions

Eligible studies will be empowerment-based nutrition interventions to improve dietary intake among adolescent girls. More specifically, we will include interventions whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation. Examples of eligible nutrition interventions are:

- Micronutrient supplementation or fortification interventions (iron, folic acid, iron–folic acid (IFA), calcium, vitamin D, vitamin A, zinc, iodine, and multiple micronutrients)
- Nutrition education or counselling interventions, and
- Supplementary nutrition programmes such as school feeding.

To be considered "empowerment-based," the nutrition intervention must include one or more activities intended to foster adolescent girls' agency, and one or more activities to create a support opportunity structure for adolescent girls' empowerment. We define activities to foster agency as those that "provide spaces for self-reflection and identification of important life areas"[53] and equip adolescent girls to make informed strategic life decisions. Examples of activities that may foster adolescent girls' agency include, but are not limited to:

- Counselling programmes
- Mentorship programmes
- Leadership training
- Life skills training
- Technical or occupational skills training

These programmes may be delivered one-on-one (e.g., individual mentorship or counselling) or in a group setting such as girls' clubs or other peer support or participatory action groups.

We define activities to create a supportive opportunity structure as those that aim to alter the constraining political, economic, sociocultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency.[22,26] Examples of opportunity structure activities include, but are not limited to:

1. Economic: Economic activities aim to increase adolescent girls' access to and control over financial and material resources. These include microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.
2. Socio-cultural: Socio-cultural activities aim to redress discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intra-household food discrimination, and programmes to support adolescent girls' completion of secondary education.
3. Legal: Legal activities aim to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights. This can include adolescent girls' rights to education, family planning, employment, or inheritance.

Nutrition-sensitive interventions, such as water, sanitation, and hygiene (WASH) programmes, agriculture programmes including community gardens, cash transfer programmes, food security programmes, and family planning programmes will be considered for inclusion if they serve as a delivery platform for an

intervention whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation and include activities to foster adolescent girls' agency.

Comparison

Studies that have a clearly defined comparison group for evaluation of the treatment effect will be included.

Types of outcome measures

- The primary outcomes for the effectiveness assessment (Research Question 1) will be measures of adolescent girls' nutritional status, including:
- Change in body mass index (BMI)
- Change in BMI-for-age z-score
- Change in mid-upper arm circumference (MUAC)
- Change in haemoglobin (g/L)
- Change in serum ferritin
- Change in anaemia status
- Change in serum vitamin A

Secondary outcomes measures for Research Question 1 are:

- Changes to dietary intake, including micronutrient intake
- Improved access to a nutritious diet
- Improved health behaviours
- Increased access or use of essential health services

We will only include studies that report at least one outcome for our population of interest.

To answer Research Question 2, our outcomes of interest are the perspectives of intervention participants (adolescent girls), providers (those who delivered the intervention), and administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors that affected intervention success or failure. These data may be qualitative, in the form of in-depth interviews, focus groups, or participant observation, or quantitative from surveys, process evaluations, and other project documentation.

To answer Research Question 3, we will extract details on the empowerment-related theories, as described by primary study authors, that were used to inform the development of the women's

empowerment-related activities. We will extract information on the activities that primary authors describe as promoting women's empowerment and the primary authors' rationale for adopting specific empowerment-related activities.

For Research Question 4, we will extract and analyse information on the empowerment dimensions and indicators used in studies to assess the impact of the empowerment-related activities on adolescent girls' empowerment outcomes. We will use the following definitions of empowerment dimensions, adapted from Brody et al. (2015) and Malhotra et al. (2002). We will classify empowerment indicators by their respective empowerment dimension for analysis.

Economic: The ability to access, own, and control resources. Potential measures include adolescent girls' control over own income; relative contribution to family support; access to and control of family resources; participation in paid employment.

Political: The ability to participate politically at the local, regional, or national level. Potential measures include knowledge of the political system and means of access to it; domestic support for political engagement; exercising the right to vote (if of legal age).

Socio-cultural: The ability to overcome discriminatory gender norms at the household and community levels. Potential measures include: Adolescent girls' freedom of movement; lack of discrimination against daughters in the household; household commitment to educating daughters.

Intrafamilial: The ability to exert power and influence in the household. Potential measures include control over sexual relations; ability to make childbearing decisions, use contraception, access abortion; control over spouse selection and marriage timing; freedom from domestic violence.

Legal: The ability to access rights and entitlements under the law. Potential measures include knowledge of legal rights; domestic support for exercising rights.

Psychological: The ability to make choices and act on them. Potential measures include self-esteem; self-efficacy; psychological well-being.

Finally, to answer Research Question 5, we will extract information on the negative or adverse effects of promoting women's empowerment in nutrition interventions for adolescent girls. These include gender-based violence, discrimination, demotivation, and adoption of unhealthy eating habits (e.g., increased consumption of sugar-sweetened beverages).

Duration of follow-up

We will include studies of any follow-up duration and will conduct sensitivity analyses by length of follow-up to test the sustainability of treatment effect.

Types of settings

Interventions delivered at home, in the community, in school, in the workplace, or in health facilities will be eligible for inclusion.

Language

No language restrictions will be applied.

Publication date

No publication data restrictions will be applied.

Search strategy

A comprehensive search strategy was developed with the assistance of an information specialist (Appendix B). Keywords used to develop the search strategy include variations on the following: "power," "empowerment," "self-efficacy," "self-determination," "personal autonomy," "agency," "women's status," "women's rights," "malnutrition," "underweight," "overweight," "diet," "micronutrient," "vitamin," "nutrition education," "school feeding," "food supplementation," "women," "girls," "female," "maternal," "adolescent," "teenager," "youth."

Databases

An experienced medical information specialist will develop and test the search strategy using an iterative process in consultation with the review authors. Another senior information specialist will peer review the search strategy prior to execution using the PRESS Checklist.

We will use a combination of controlled vocabulary (e.g., "Power [Psychology]," "Women's Rights," "Nutritional Status") and key words (e.g., empower, female status, and diet) for the concepts in all searches. We will apply the Cochrane filter for low- and middle-income countries. Vocabulary and syntax will be adjusted as necessary across the databases. We will remove animal-only and opinion pieces from the results whenever possible.

Using the OVID platform, we will search Ovid MEDLINE®, including Epub Ahead of Print and In-Process & Other Non-Indexed Citations, Embase Classic + Embase, PsycINFO, and the following EBM

Reviews databases: Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Health Technology Assessment, and the NHS Economic Evaluation Database. We will also search CINAHL (Ebsco platform), Web of Science, and Popline. We will document the search process in enough detail to ensure that it can be reported correctly in the review/update, including reporting the month and year the search began and ended.

Grey literature and hand searching

To identify potentially relevant unpublished materials, we will contact the following research groups and organisations, and/or consult their respective websites:

- World Health Organisation Library (includes LILACS)
- Epistemonikos
- 3ie Impact and Systematic Review repositories
- E-Library of Evidence for Nutrition Actions (eLENA)
- UNICEF
- World Food Programme
- UNFPA
- International Food Policy Research Institute (IFPRI)
- Global Alliance for Improved Nutrition (GAIN)
- Nutrition International
- SPRING Project
- International Centre for Research on Women (ICRW)
- UN Women
- Gender and Adolescence: Global Evidence (GAGE) Programme
- U.K. Department of International Development (DfID)
- Bill and Melinda Gates Foundation
- Plan International
- CARE
- Save the Children
- World Vision
- Young Lives
- Emergency Nutrition Network

Citation and reference lists

The citation and reference lists of included references, including other reviews, will be searched. “Related articles” features of searched databases will be used, where applicable. We will conduct forward citation tracking using Scopus.

Contacting experts

We will contact authors of included studies to ask for suggested studies.

Screening of studies

Study selection will be conducted in duplicate by two independent reviewers using the Covidence platform (www.covidence.org). Titles and abstracts resulting from the search strategy will be independently screened by two reviewers in the first phase, followed by independent full-text review of eligible studies, also in duplicate. Any discrepancies between the independent reviewers will be resolved by consensus, and in cases of disagreement, a third author will be consulted. A PRISMA study selection flow chart [65]will be prepared, and a list of excluded studies will be compiled detailing the reason for each study’s exclusion.

To minimise the risk of excluding eligible studies, we will screen for nutrition-related activities only at the title and abstract phase. In other words, we screen in all studies that aim to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation when screening titles and abstracts. At the full-text screening stage we will further screen for the agency and opportunity structure components to determine study eligibility. In instances where articles do not provide a sufficient description of the intervention to determine its eligibility, we will look for companion articles describing the intervention or contact the authors for additional information. Where we cannot obtain additional information on the intervention, the studies will be excluded from the review.

Description of methods used in primary research

The following study is an example of the expected eligible primary research methods:

Hewett et al. (2017): Multi-arm cluster-RCT across 10 sites in four provinces of Zambia with randomisation to four different study arms (Intervention Arm 1, Intervention Arm 2, Intervention Arm 3, Control). The sites were evenly split between urban and rural settings (five sites each). The intervention assessed the effectiveness of the Adolescent Girls Empowerment Programme (AGEP), which consisted of weekly mentor-led girls’ group meetings of 20 to 30 adolescent girls, participating over 2 years using curricula on sexual and reproductive health and life skills, financial literacy, and nutrition. Two additional

components were a health voucher and bank account. Clusters were defined by national Census Supervisory Areas (CSAs) that were randomly selected to the experimental and control arms through a public lottery. Allocation concealment was unclear. Baseline behavioural surveys and biological specimen collection were conducted at the beginning of the trial, reassessed immediately after the programme ended (2015), and evaluated again at the 2-year follow-up point (2017). It is unclear if a cluster-adjustment method was applied.[54]

Criteria for the determination of independent findings

Where studies report different outcomes, these will be pooled in separate meta-analyses. If there are several publications reporting on the same study, we will use effect sizes from the most recent publication. In cases where several studies use the same data set or multiple outcomes are reported within the same study, we will select the study that provides the lowest risk of bias in attributing impact. Where studies include multiple outcome measures to assess related outcome constructs, we will select the outcome that appears to most accurately reflect the outcome construct of interest.[66] For studies in which multiple effects over time are reported, a variance estimation meta-analysis will be conducted. For studies having multiple treatments with only one control group, where the treatments might represent separate treatment constructs, we will calculate the effect size for each pair of treatment versus control separately.

Details of study coding categories

The quality assessment of included studies and data extraction will be done by two independent reviewers.

Quality assessment

We will use the risk of bias tool developed by the International Development Coordinating Group (IDCG) secretariat to assess risk of bias, similar to Baird, Ferreira, Özler, and Woolcock.[67] This tool has been developed to assess the risk of bias for a range of experimental and quasi-experimental studies. The tool assesses risk of bias in the following categories:

- Selection bias and confounding
- Spill-overs/crossovers/contamination
- Outcome reporting
- Analysis reporting

Other risks of bias, including unit of analysis errors, detection bias and placebo effects, motivation and courtesy biases, coherence of results, and others.

Judgements made on risk of bias in quantitative studies will be supported by specific information extracted from the study being assessed. An overall level of evidence quality (high, moderate, low, and very low) for the entire body of evidence will be assigned as part of the GRADE process.[68]

We will assess the quality of qualitative studies using the Critical Appraisal Skills Programme (CASP) qualitative appraisal research tool.[69] The GRADE-CERQual approach will be used to assess the overall confidence in the qualitative evidence synthesis.[70] GRADE-CERQual provides an assessment of confidence regarding the extent to which the research finding is likely to be substantially different from the phenomenon of interest. A level of confidence in the review findings will be assigned, ranging from high, moderate, low to very low confidence.[70]

Data extraction

Data extraction will be conducted in duplicate by two independent reviewers. Both reviewers will use a pre-piloted data extraction form. Discrepancies between the two extractors will be resolved through discussion or by consultation with a third reviewer. See Appendix C for draft codebooks that will guide data extraction.

The following information on intervention design will be extracted:

- The intervention setting, e.g., school, community, home, workplace so forth.
- The intervention administrator, e.g., foreign government, national or local government, nongovernmental organisation, community-based organisation so forth.
- The intervention provider, e.g., community health worker, health facility staff, teachers, peers, and so forth.
- Descriptions of any training given to intervention providers before and during the intervention
- Description of any prior needs assessment to inform intervention design
- Participant recruitment procedures
- Participant attrition rate and reasons for attrition
- Activities undertaken to design the intervention in a culturally sensitive manner
- Intervention reach (the degree to which participants are present and participate)
- Intervention dose (frequency, intensity and duration of intervention delivery to participants
- Intervention integrity/fidelity (degree to which the intervention was delivered according to original design)
- Intervention adaptation (adaptation during implementation to respond to changing circumstances)

- Contamination (unintentional delivery of intervention to comparison group or failure to provide intervention to intervention group)
- Cointervention (unintentional delivery of another intervention to study population)
- Participant engagement (active participation and receptivity to the intervention)
- Intervention quality
- Contextual factors that shape implementation effectiveness (e.g., level of food insecurity)
- Authors' definition of empowerment and rationale for incorporating empowerment-related activities

For quantitative outcomes, we will extract the following:

- For dichotomous outcomes, we will extract the total number of participants in the treatment group and the total number experiencing the event to allow the calculation of odds ratios and relative risks (or data necessary for their calculation).
- For normally-distributed, continuous outcomes, we will extract means, standard deviations (or data necessary for their estimation) and the number of participants in each treatment group.
- For skewed continuous data, we will extract medians, ranges, and p values. Outcomes that were measured at different time points will be recorded separately.

For measures of empowerment, we will extract definitions of the measures used, the empowerment dimensions being measured (according to the primary authors), and the primary authors' rationale for outcome selection.

We will extract data on socioeconomic status, education level, race/ethnicity/caste, place of residence (urban, rural, slum, remote), and other potential effect moderators for subgroup analyses based on the PROGRESS-Plus framework.[59]

Quantitative data will be entered into RevMan5 and checked for accuracy.

For qualitative studies, we will extract the views, experiences, and opinions of intervention participants, implementers and administrators on factors influencing the success or failure of interventions. Emphasis will be placed on ascertaining the feasibility, appropriateness, and meaningfulness of the women's empowerment components of the intervention.

Statistical procedures and conventions

Quantitative data will be synthesised using meta-analysis, where appropriate. We expect a high level of heterogeneity due to the fact that studies may employ a variety of different nutrition, agency, and

opportunity structure activities. Consequently, we will use a random effects model to produce an overall summary estimate if an average treatment effect across studies is considered meaningful. Where meta-analysis is not possible or is deemed inappropriate, results will be reported using narrative synthesis, giving effect sizes and confidence intervals, where applicable.[71]

We will assess heterogeneity among studies by first examining the heterogeneity at face-value in terms of the studies' populations, interventions, and outcomes. Second, we will use $\tau 2$ to statistically test heterogeneity between studies. $\tau 2$ is the variance of the effect size parameters across the population of studies and reflects the variance of the true effect sizes.[72,73]

The accuracy of numeric data will be checked by comparing the magnitude and direction of effects reported by studies and how they are presented in the review. A statistically nonsignificant p value will be interpreted as a finding of uncertainty unless confidence intervals are sufficiently narrow to rule out an important magnitude of effect.

Our base-case analysis will include all interventions regardless of nutrition, agency or opportunity structure intervention. If there is a sufficient number of studies, we will conduct the following sensitivity analyses based on intervention design (Table 2).

Table 2. Sensitivity tests by intervention design.

Test	Nutrition	Agency	Opportunity structure
Base case	All nutrition activities combined	All agency activities combined	All opportunity structure activities combined
Test 1	All nutrition activities combined	All agency activities combined	Opportunity structure activities split by dimension
Test 2	All nutrition activities combined	Agency activities split by group vs nongroup activities	All opportunity structure activities combined
Test 3	Nutrition activities split by promotion of a healthy diet, providing additional micronutrients, or a combination of both	All agency activities combined	All opportunity structure activities combined

Should the number of studies warrant, we will further split the interventions and run further sensitivity analyses. For example, we will consider sensitivity tests that break down all three intervention elements. Otherwise, we will provide a narrative summary.

We will combine experimental and quasi-experimental designs for analysis and conduct a sensitivity analysis by study design. We will use David Wilson's effect size calculator for quasi-experimental study

outcomes to allow for combining of experimental and quasi-experimental study outcomes for meta-analysis.[73]

Primary and secondary outcome data will be extracted and analyzed separately. Binary outcomes (e.g., anaemia status) will be analyzed using risk ratios (±95% confidence interval [CI]). Continuous outcomes (e.g., height and weight) will be analyzed using mean differences (±95% CI) and standardised mean differences when different units are used (e.g., measures of dietary diversity or empowerment indicators). In the random effects meta-analysis, Mantel-Haenszel (M-H) methods will be used for binary outcomes, and the Inverse-Variance (I-V) method will be used for continuous outcomes. Where studies use different metrics for the same outcome, e.g., anemia status (binary) vs haemoglobin (continuous), we will convert to the same metric using Borenstein's conversion formulae [72] and synthesise.

Unit of analysis errors will be investigated to ensure estimates are properly adjusted for clustering. Where analyses are not adjusted for clustering, estimates will be adjusted using values of intra-cluster correlations from the literature. An intention-to-treat analysis will be conducted. We will document how authors treated missing data, and the effect of missing data on the overall results will be assessed through sensitivity analysis.

We will conduct moderator analyses on the following:

- Risk of bias (low, unclear, and high)
- Study duration
- Low-income country vs. middle-income country
- Geographic region (Africa, Asia, and Latin America)
- Study design (RCT vs. NRS)
- Group vs. nongroup interventions
- Marital status (single, currently partnered, divorcee/separated/widowed)
- Number of children (0 vs. 1+)
- Education level (none, some primary, primary complete, some secondary, secondary complete, and higher)
- Age (10–14 y vs. 15–19 y)

A formal statistical test will be used to test differences between groups. For subgroups defined by binary or nominal categories, we will use the Cochran Q-test. For ordinal categories, multi-level meta-analysis will be conducted. The results of all subgroup testing will be reported, regardless of results.

If more than ten studies meet our eligibility criteria, we will assess the presentation of publication bias using a visual inspection of funnel plots. Statistical support will be provided by a statistician, and meta-analyses will be conducted using RevMan5 software. Results will be displayed using forest plots.

The level of evidence will be considered when formulating the review's conclusions. Where possible, differences in results will be explained by giving a description of likely explanatory factors. We will prepare a GRADE summary of findings table.[74]

Treatment of qualitative research

We will use the "best fit" framework synthesis method to synthesise data (Carroll, Booth, Leaviss, & Rick, 2013; Harden et al., 2018). The "best fit" framework synthesis method allows for the testing or adaption of an existing model to a potentially different population. For this review, we have adapted existing models for nutrition and women's empowerment to develop a logic model (described earlier) for adolescent girls' empowerment and nutrition, and plan to test its applicability through the systematic review process. We will code qualitative data from the review's included studies against the conceptual framework at each level of the conceptual framework:

1. Elements of the approach
    a. Nutrition-related activities
    b. Agency-related activities
    c. Opportunity structure activities
2. Outputs (or implementation factors)
    a. Intervention setting
    b. Intervention administrator
    c. Intervention provider
    d. Provider training
    e. Prior needs assessment to inform intervention design
    f. Participant recruitment procedures
    g. Participant attrition rate and reasons for attrition
    h. Activities undertaken to design the intervention in a culturally sensitive manner
    i. Intervention reach
    j. Intervention dose
    k. Intervention integrity/fidelity
    l. Intervention adaptation
    m. Contamination

    n. Cointervention
    o. Participant engagement
    p. Intervention quality
3. Shorter-term outcomes
    a. Increased ability and motivation to make and act on informed choices to improve nutritional status
    b. Supportive home and community environment to support adolescent girls' choices
    c. Improved awareness, knowledge and skills for the adoption of a healthy diet and positive health behaviours
4. Intermediate-term outcomes
    a. Increased decision-making power
    b. Increased access to or control over resources
    c. Protection and fulfilment of human rights
    d. Improved access to a nutritious diet
    e. Increase use of essential health services
    f. Improved health behaviours
5. Longer-term outcomes
    a. Improved dietary intake
    b. Reduced risk of disease, infection, injury, and early pregnancy
    c. Adverse effects
6. Contextual factors
    a. Macro-level
    b. Community level
    c. Household level
    d. Individual level

Inductive, thematic analysis techniques will be used to synthesise data that do not align to the existing themes in the logic model. Emphasis will be placed on understanding the role that promoting women's empowerment in the nutrition sector programme had on intervention success or failure, with a focus on aspects regarding the feasibility, appropriateness and meaningfulness of the empowerment- related activities or strategies that were employed. The conclusions drawn from the quantitative and qualitative syntheses will be combined to inform the review's final discussion and conclusions. The logic model will be revised based on the review's conclusions. The review's discussion will include reflections on the review's policy and future research implications.

Roles and responsibilities

Content: AYR, ZAB, CV, EK, AKR, CMK

Systematic review methods: AYR, GAW, VW, EK

Statistical analysis: AYR, GAW, MT

Information retrieval: BS

Sources of support

The lead author (AYR.) is the recipient of a graduate studentship award from the Bruyère Research Institute, and a PhD grant from Nutrition International.

Declarations of interest

AYR, CMK, AKR., ZAB, CV, EB, CK, and LS have no conflicts of interest to declare. VW is the Editor-in-Chief of the Campbell Collaboration.

Preliminary timeline

Approximate date for submission of the systematic review: March 2020.

Plans for updating the review

The review will be updated every two years. AYR will be responsible for updating the review.

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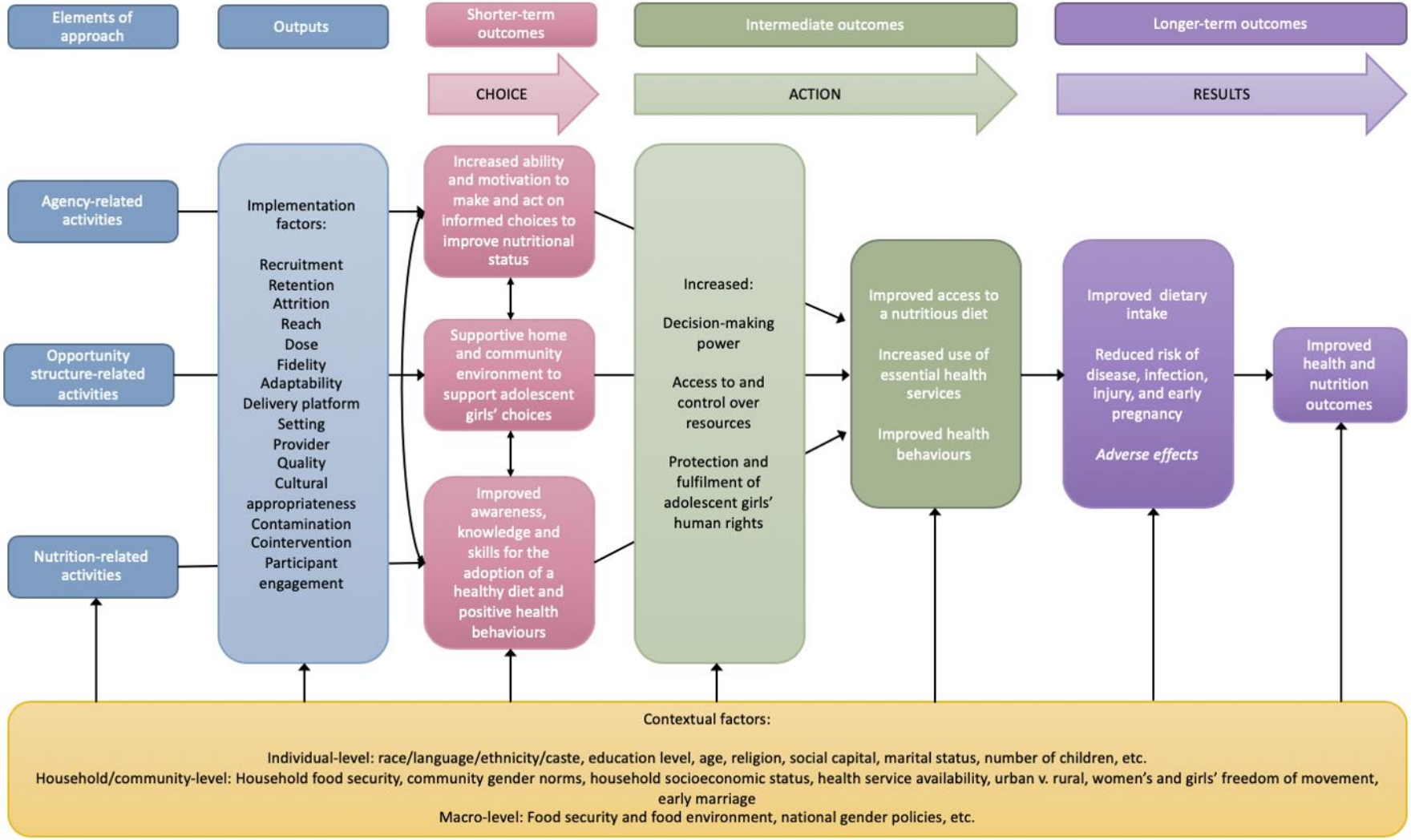
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Appendix A: Logic model



Appendix B: Medline search strategy

1 "Power (Psychology)"/ (158608)
2 Attitude/ (107645)
3 Attitude to Health/ (190744)
4 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (41819)
5 Intention/ (171233)
6 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (8807)
7 Motivation/ (216063)
8 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (13802)
9 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (14391)
10 Self Efficacy/ (92885)
11 Personal Autonomy/ (29331)
12 Self Concept/ (184924)
13 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw,kf. (2505725)
14 (abilit* adj3 (act or acted or acting or acts or action?)).tw,kf. (7288)
15 Women's Rights/ (15820)
16 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw,kf. (36459)
17 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw,kf. (74261)
18 (active$2 adj2 (engag* or involv* or participat*)).tw,kf. (61724)
19 participatory.tw,kf. (35824)
20 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw,kf. (21145)
21 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw,kf. (31601)
22 Gender Identity/ (41227)
23 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw,kf. (28904)
24 Social Norms/ (10338)
25 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw,kf. (36015)
26 or/1-25 (3571314)
27 Nutritional Requirements/ (37442)
28 Nutritional Status/ (105385)
29 Nutritive Value/ (30809)
30 Adolescent Nutritional Physiological Phenomena/ (1838)
31 Maternal Nutritional Physiological Phenomena/ (13721)
32 Malnutrition/ (75398)
33 exp Deficiency Diseases/ (260675)
34 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw,kf. (8831)
35 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (4094)
36 scurvy.tw,kf. (4345)

37 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (1959)
38 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (7851)
39 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw,kf. (17888)
40 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw,kf. (15262)
41 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (1819)
42 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (2802)
43 pellagra.tw,kf. (2774)
44 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (3255)
45 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (7920)
46 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (2773)
47 Overnutrition/ (5853)
48 exp Obesity/ (711110)
49 Growth Disorders/ (26038)
50 ((growth adj2 stunt$2) or stunting).tw,kf. (14027)
51 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw,kf. (1769168)
52 Anemia/ (242868)
53 exp Anemia, Hypochromic/ (46742)
54 (an?emic or an?emia* or chloros#s).tw,kf. (387455)
55 Feeding Behavior/ (172106)
56 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw,kf. (141785)
57 Diet/ (402699)
58 (diet or dieted or diets or dietary or dieting).tw,kf. (1174789)
59 Energy Intake/ (93531)
60 ((calori* or energy or protein?) adj3 intak*).tw,kf. (115306)
61 Healthy Diet/ (4701)
62 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw,kf. (39237)
63 exp Micronutrients/ (688381)
64 (micronutri* or micro-nutri*).tw,kf. (35383)
65 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw,kf. (44266)
66 Calcium, Dietary/ (31557)
67 Chromium/ (59565)
68 Copper/ (178475)
69 Iodine/ (75382)
70 Iron/ (259984)
71 Manganese/ (74289)
72 Molybdenum/ (21257)
73 Selenium/ (58025)
74 Zinc/ (170532)

75 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw,kf. (1924054)
76 vitamin*.tw,kf. (512331)
77 exp Dietary Supplements/ (89126)
78 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw,kf. (25906)
79 n?utr#ceutical?.tw,kf. (14005)
80 Food, Fortified/ (11093)
81 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw,kf. (25026)
82 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw,kf. (19850)
83 Food Supply/ (28920)
84 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw,kf. (31860)
85 or/27-84 (6032125)
86 26 and 85 (298093)
87 Developing Countries/ (159704)
88 Africa/ or Asia/ or Caribbean/ or West Indies/ or South America/ or Latin America/ or Central America/ (228463)
89 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).tw,kf. (2468939)
90 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or

south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)
91 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw,kf. (262888)
92 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw,kf. (3030)
93 (low* adj (gdp or gnp or gross domestic or gross national)).tw,kf. (641)
94 (low adj3 middle adj3 countr*).tw,kf. (31752)
95 (lmic or lmics or third world or lami countr*).tw,kf. (16026)
96 transitional countr*.tw,kf. (457)
97 or/87-96 (3718691)
98 86 and 97 (32745)
99 Women/ (8405706)
100 Pregnant Women/ (69649)
101 Female/ and (Adolescent/ or Adult/ or Young Adult/) (9600899)
102 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw,kf. (4328988)
103 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw,kf. (286629)
104 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw,kf. (28995)
105 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw,kf. (66012)
106 young girl?.tw,kf. (10028)
107 or/99-106 (15081858)
108 98 and 107 (19470)
109 exp Animals/ not Humans/ (17546303)
110 108 not 109 [ANIMAL-ONLY REMOVED] (13985)
111 (comment or editorial or news or newspaper article).pt. (1896536)
112 (letter not (letter and randomized controlled trial)).pt. (2072075)
113 110 not (111 or 112) [OPINION PIECES REMOVED] (13938)
114 113 use medall [MEDLINE RECORDS] (6474)
115 empowerment/ (27108)

116 attitude/ (107645)
117 attitude to health/ (190744)
118 attitude to life/ (657)
119 maternal attitude/ (2423)
120 attitude to pregnancy/ (580)
121 social attitude/ (2312)
122 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (45396)
123 behavior/ (209991)
124 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (9069)
125 motivation/ (216063)
126 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (14513)
127 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (14391)
128 personal autonomy/ (29331)
129 exp self concept/ (373341)
130 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw,kw. (2512016)
131 (abilit* adj3 (act or acted or acting or acts or action?)).tw,kw. (7289)
132 women's rights/ (15820)
133 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw,kw. (36781)
134 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw,kw. (74297)
135 (active$2 adj2 (engag* or involv* or participat*)).tw,kw. (61734)
136 participatory*.tw,kw. (36423)
137 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw,kw. (21169)
138 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw,kw. (31657)
139 gender identity/ (41227)
140 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw,kw. (28723)
141 social norm/ (10891)
142 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw,kw. (36159)
143 or/115-142 (3718206)
144 nutrition/ (124564)
145 nutritional health/ (6190)
146 exp nutritional requirement/ (39461)
147 exp nutritional status/ (106035)
148 nutritional value/ (31912)
149 adolescent nutrition/ (202)
150 maternal nutrition/ (11173)
151 malnutrition/ (75398)
152 exp nutritional deficiency/ (283978)
153 exp protein deficiency/ (44783)
154 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw,kw. (8961)

155 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (4087)
156 scurvy.tw,kw. (4353)
157 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2055)
158 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (7851)
159 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw,kw. (17918)
160 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw,kw. (15531)
161 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (1816)
162 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2805)
163 pellagra.tw,kw. (2772)
164 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (3220)
165 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (7929)
166 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2690)
167 exp overnutrition/ (694990)
168 growth disorder/ (33286)
169 stunting/ (19313)
170 ((growth adj2 stunt$2) or stunting).tw,kw. (14278)
171 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw,kw. (1793960)
172 anemia/ (242868)
173 iron deficiency anemia/ (37358)
174 (an?emic or an?emia* or chloros#s).tw,kw. (395051)
175 eating habit/ (99906)
176 feeding behavior/ (172106)
177 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw,kw. (144241)
178 diet/ (402699)
179 (diet or dieted or diets or dietary or dieting).tw,kw. (1187821)
180 caloric intake/ (96310)
181 ((calori* or energy or protein?) adj3 intak*).tw,kw. (117328)
182 dietary intake/ (73687)
183 healthy diet/ (4701)
184 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw,kw. (39335)
185 exp nutrient/ (677172)
186 nutrient availability/ (3222)
187 nutrient content/ (5017)
188 nutrient limitation/ (1029)
189 nutrient supply/ (2308)
190 nutrient uptake/ (2874)

191 (micronutri* or micro-nutri*).tw,kw. (36132)
192 exp trace element/ (366886)
193 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw,kw. (46036)
194 chromium/ (59565)
195 copper/ (178475)
196 iodine/ (75382)
197 manganese/ (74289)
198 molybdenum/ (21257)
199 selenium/ (58025)
200 zinc/ (170532)
201 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw,kw. (1949030)
202 vitamin/ (89429)
203 vitamin*.tw,kw. (522115)
204 dietary supplement/ (61637)
205 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw,kw. (26015)
206 nutraceutical/ (64077)
207 n?utr#ceutical?.tw,kw. (14562)
208 fortified food/ (11096)
209 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw,kw. (25657)
210 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw,kw. (20058)
211 food availability/ (3871)
212 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw,kw. (31599)
213 or/144-212 (6081563)
214 143 and 213 (313876)
215 developing country/ (165162)
216 (Africa or Asia or Caribbean or West Indies or South America or Latin America or Central America).hw,tw,kw. (640442)
217 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint

Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).hw,tw,kw. (3320872)
218 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)
219 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw,kw. (237596)
220 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw,kw. (3036)
221 (low* adj (gdp or gnp or gross domestic or gross national)).tw,kw. (645)
222 (low adj3 middle adj3 countr*).tw,kw. (31748)
223 (lmic or lmics or third world or lami countr*).tw,kw. (16181)
224 transitional countr*.tw,kw. (462)
225 or/215-224 (4044608)
226 214 and 225 (36165)
227 exp named groups by pregnancy/ (101747)
228 pregnant woman/ (82942)
229 female/ and (adult/ or young adult/ or juvenile/ or adolescent/ or adolescent parent/) (9605834)
230 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw,kw. (4340623)
231 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw,kw. (292884)
232 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw,kw. (28995)

233 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw,kw. (66013)
234 young girl?.tw,kw. (10038)
235 or/227-234 (12506222)
236 226 and 235 (20195)
237 exp animal/ or exp animal experimentation/ or exp animal model/ or exp animal experiment/ or nonhuman/ or exp vertebrate/ (50805119)
238 exp human/ or exp human experimentation/ or exp human experiment/ (38981083)
239 237 not 238 (11825722)
240 236 not 239 [ANIMAL-ONLY REMOVED] (20036)
241 editorial.pt. (1081172)
242 letter.pt. not (letter.pt. and randomized controlled trial/) (2071940)
243 240 not (241 or 242) [OPINION PIECES REMOVED] (19985)
244 243 use emczd [EMBASE RECORDS] (9903)
245 Social Identity/ (105394)
246 Group Identity/ (1322)
247 Attitudes/ (72109)
248 Community Attitudes/ (2559)
249 Death Attitudes/ (19039)
250 Eating Attitudes/ (1539)
251 Female Attitudes/ (1625)
252 Health Attitudes/ (94051)
253 exp Sex Role Attitudes/ (12044)
254 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (41335)
255 exp Intention/ (3953989)
256 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (8802)
257 Motivation/ (216063)
258 Expectations/ (81852)
259 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (13785)
260 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (14391)
261 Self-Efficacy/ (92885)
262 "Independence (Personality)"/ (4988)
263 Self-Determination/ (20619)
264 Self-Concept/ (184924)
265 Self-Confidence/ (57437)
266 Self-Esteem/ (101452)
267 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw. (2502151)
268 (abilit* adj3 (act or acted or acting or acts or action?)).tw. (7288)
269 Self-Perception/ (146381)
270 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw. (34478)
271 Involvement/ (6748)
272 Participation/ (7668)

273 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw. (74248)
274 (active$2 adj2 (engag* or involv* or participat*)).tw. (61718)
275 participatory*.tw. (35257)
276 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw. (21143)
277 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw. (31568)
278 Gender Equality/ (667)
279 Role Expectations/ (1621)
280 Sex Roles/ (34691)
281 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw. (28694)
282 Social Norms/ (10338)
283 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw. (35820)
284 or/245-283 (6964179)
285 Nutrition/ (124564)
286 exp Nutritional Deficiencies/ (124075)
287 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw. (8621)
288 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (3989)
289 scurvy.tw. (3901)
290 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (1959)
291 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (7797)
292 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw. (17757)
293 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw. (15197)
294 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (1792)
295 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (2784)
296 pellagra.tw. (2584)
297 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (3196)
298 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (7817)
299 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (2639)
300 Obesity/ (598386)
301 ((growth adj2 stunt$2) or stunting).tw. (13942)
302 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw. (1748835)
303 Anemia/ (242868)
304 (an?emic or an?emia* or chloros#s).tw. (380030)
305 Eating Behavior/ (174683)

306 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw. (141008)
307 Diets/ (161532)
308 (diet or dieted or diets or dietary or dieting).tw. (1165001)
309 Food Intake/ (184009)
310 ((calori* or energy or protein?) adj3 intak*).tw. (115118)
311 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw. (39122)
312 (micronutri* or micro-nutri*).tw. (35029)
313 Metallic Elements/ (436)
314 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw. (43646)
315 exp Calcium/ (570689)
316 Copper/ (178475)
317 Iron/ (259984)
318 Zinc/ (170532)
319 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw. (1900718)
320 Vitamins/ (89507)
321 vitamin*.tw. (499855)
322 Dietary Supplements/ (67852)
323 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw. (25555)
324 n?utr#ceutical?.tw. (13721)
325 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw. (24593)
326 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw. (19806)
327 Food Deprivation/ (18608)
328 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw. (30873)
329 or/285-328 (5847359)
330 284 and 329 (656017)
331 Developing Countries/ (159704)
332 (Africa? or Asia? or Caribbean or West Indies or South America? or Latin America? or Central America?).tw. (924816)
333 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New

Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).tw. (2449161)
334 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw. (233745)
335 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw. (3024)
336 (low* adj (gdp or gnp or gross domestic or gross national)).tw. (641)
337 (low adj3 middle adj3 countr*).tw. (31256)
338 (lmic or lmics or third world or lami countr*).tw. (15802)
339 transitional countr*.tw. (456)
340 or/331-339 (3253265)
341 330 and 340 (74884)
342 Adolescent Mothers/ (2282)
343 Expectant Mothers/ (637)
344 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw. (4311022)
345 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw. (285627)
346 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw. (28995)
347 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw. (66012)
348 young girl?.tw. (10026)
349 or/342-348 (4596550)
350 Human Females/ (88344)
351 Wives/ (13136)
352 350 or 351 (101298)
353 limit 352 to (200 adolescence <age 13 to 17 yrs> or 320 young adulthood <age 18 to 29 yrs> or 340 thirties <age 30 to 39 yrs> or 360 middle age <age 40 to 64 yrs>) [Limit not valid in Embase,Ovid MEDLINE(R),Ovid MEDLINE(R) Daily Update,Ovid MEDLINE(R) In-Process,Ovid MEDLINE(R) Publisher,CCTR,CDSR,DARE,CLHTA,CLEED; records were retained] (43270)
354 349 or 353 (4605043)
355 341 and 354 (27908)
356 355 use medall,emczd,cctr,coch,dare,clhta,cleed (26667)
357 355 not 356 [PSYCINFO RECORDS] (1241)
358 "Power (Psychology)"/ (158608)
359 Attitude/ (107645)
360 Attitude to Health/ (190744)
361 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (42279)
362 Intention/ (171233)
363 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (8886)
364 Motivation/ (216063)

365 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (14263)
366 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (14226)
367 Self Efficacy/ (92885)
368 Personal Autonomy/ (29331)
369 Self Concept/ (184924)
370 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).ti,ab,kw. (2484054)
371 (abilit* adj3 (act or acted or acting or acts or action?)).ti,ab,kw. (7236)
372 Women's Rights/ (15820)
373 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).ti,ab,kw. (36005)
374 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).ti,ab,kw. (73351)
375 (active$2 adj2 (engag* or involv* or participat*)).ti,ab,kw. (61322)
376 participatory*.ti,ab,kw. (35693)
377 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).ti,ab,kw. (20803)
378 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).ti,ab,kw. (31346)
379 Gender Identity/ (41227)
380 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).ti,ab,kw. (27434)
381 Social Norms/ (10338)
382 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).ti,ab,kw. (34970)
383 or/358-382 (3552165)
384 Nutritional Requirements/ (37442)
385 Nutritional Status/ (105385)
386 Nutritive Value/ (30809)
387 Adolescent Nutritional Physiological Phenomena/ (1838)
388 Maternal Nutritional Physiological Phenomena/ (13721)
389 Malnutrition/ (75398)
390 exp Deficiency Diseases/ (260675)
391 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).ti,ab,kw. (8948)
392 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (4074)
393 scurvy.ti,ab,kw. (4341)
394 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2037)
395 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (7843)
396 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).ti,ab,kw. (17838)
397 (hyperhomocystein?emi* or hyper-homocystein?emi*).ti,ab,kw. (15508)
398 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (1808)

399 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2791)
400 pellagra.ti,ab,kw. (2759)
401 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (3214)
402 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (7904)
403 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2684)
404 Overnutrition/ (5853)
405 exp Obesity/ (711110)
406 Growth Disorders/ (26038)
407 ((growth adj2 stunt$2) or stunting).ti,ab,kw. (14204)
408 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).ti,ab,kw. (1787088)
409 Anemia/ (242868)
410 exp Anemia, Hypochromic/ (46742)
411 (an?emic or an?emia* or chloros#s).ti,ab,kw. (393916)
412 Feeding Behavior/ (172106)
413 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).ti,ab,kw. (141188)
414 Diet/ (402699)
415 (diet or dieted or diets or dietary or dieting).ti,ab,kw. (1184491)
416 Energy Intake/ (93531)
417 ((calori* or energy or protein?) adj3 intak*).ti,ab,kw. (116855)
418 Healthy Diet/ (4701)
419 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).ti,ab,kw. (39049)
420 exp Micronutrients/ (688381)
421 (micronutri* or micro-nutri*).ti,ab,kw. (35918)
422 (trace element? or trace mineral? or micromineral? or micro-mineral?).ti,ab,kw. (45946)
423 Calcium, Dietary/ (31557)
424 Chromium/ (59565)
425 Copper/ (178475)
426 Iodine/ (75382)
427 Iron/ (259984)
428 Manganese/ (74289)
429 Molybdenum/ (21257)
430 Selenium/ (58025)
431 Zinc/ (170532)
432 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).ti,ab,kw. (1944286)
433 vitamin*.ti,ab,kw. (520663)
434 exp Dietary Supplements/ (89126)
435 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).ti,ab,kw. (25760)
436 n?utr#ceutical?.ti,ab,kw. (14503)
437 Food, Fortified/ (11093)
438 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).ti,ab,kw. (25516)

439 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).ti,ab,kw. (19800)
440 Food Supply/ (28920)
441 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).ti,ab,kw. (31461)
442 or/384-441 (6067800)
443 383 and 442 (295635)
444 Developing Countries/ (159704)
445 Africa/ or Asia/ or Caribbean/ or West Indies/ or South America/ or Latin America/ or Central America/ (228463)
446 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).ti,ab,kw. (2446958)
447 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or

philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)
448 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).ti,ab,kw. (234706)
449 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).ti,ab,kw. (2988)
450 (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab,kw. (643)
451 (low adj3 middle adj3 countr*).ti,ab,kw. (30878)
452 (lmic or lmics or third world or lami countr*).ti,ab,kw. (15985)
453 transitional countr*.ti,ab,kw. (445)
454 or/444-453 (3687965)
455 443 and 454 (30919)
456 Women/ (8405706)
457 Pregnant Women/ (69649)
458 Female/ and (Adolescent/ or Adult/ or Young Adult/) (9600899)
459 (woman* or women* or matern* or mother* or wife or wives or pregnan*).ti,ab,kw. (4324318)
460 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).ti,ab,kw. (284320)
461 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).ti,ab,kw. (28338)
462 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).ti,ab,kw. (65402)
463 young girl?.ti,ab,kw. (9994)
464 or/456-463 (15074516)
465 455 and 464 (18238)
466 465 use coch,cctr,dare,clhta,cleed [COCHRANE RECORDS] (925)
467 114 or 244 or 357 or 466 [ALL DATABASES] (18543)
468 limit 467 to yr="2016-current" [Limit not valid in DARE; records were retained] (5061)
469 remove duplicates from 468 (3740)
470 limit 467 to yr="2011-2015" [Limit not valid in DARE; records were retained] (5957)
471 remove duplicates from 470 (4296)
472 limit 467 to yr="2000-2010" [Limit not valid in DARE; records were retained] (4760)
473 remove duplicates from 472 (3258)
474 467 not (468 or 470 or 472) (2767)
475 remove duplicates from 474 (2200)
476 469 or 471 or 473 or 475 [TOTAL UNIQUE RECORDS] (13492)
477 476 use medall [MEDLINE UNIQUE RECORDS] (6468)
478 476 use emczd [EMBASE UNIQUE RECORDS] (5659)
479 476 use medal, emczd, coch, cctr, dare, cleed, clhta (12605)
480 476 not 479 [PSYCINFO UNIQUE RECORDS] (887)
481 476 use coch [DSR UNIQUE RECORDS] (4)

482 476 use dare [DARE UNIQUE RECORDS] (1)
483 476 use cleed [NHS UNIQUE RECORDS] (0)
484 476 use clhta [HTA UNIQUE RECORDS] (0)
485 476 use CCTR [CENTRAL UNIQUE RECORDS] (473)

Appendix C: Quantitative study codebook

Where possible, provide direct quotes and page numbers to support your extractions.

Code	Description
Study ID	from Covidence
Date coded	
Coder initials	
Correspondence required	Add a note here if authors will need to be contacted to request additional information
Reference identification	
Title	
First author	
Year	
Type of publication	(drop-down) Journal article / Book / Conference abstract / Dissertation / Report / Other
Other	Define 'other' publication type
Funder	
Country	
City and region (if applicable)	
Start date of study	
End date of study	
Study duration	
Aim of the study	
Authors' definition of empowerment	
Authors' rationale for empowerment approach	
Methods	
Study design	(drop-down) RCT / cRCT / CBA / ITS / Other
Other	Define 'other' study design type
Study design description	
Comparison group	Describe the nature of the comparison group
Statistical method	Describe method used and comment on appropriateness.
Risk of bias - Experimental designs (Cochrane ROB)	
Random sequence generation	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Allocation concealment	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Blinding of participants	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Blinding of outcome assessment	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Incomplete outcome assessment	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Selective outcome reporting	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	

Other sources of bias	(drop-down) High risk / Low risk / Unclear
Support for judgement (incl. pg #)	
Risk of bias - Quasi-experimental designs (Cochrane EPOC)	
For CCTs, CBAs	
Was the allocation sequence adequately generated?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the allocation adequately concealed?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Were baseline outcome measurements similar?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Were baseline characteristics similar?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Were incomplete outcome data adequately addressed?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was knowledge of the allocated interventions adequately prevented during the study?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the study adequately protected against contamination?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the study free from selective outcome reporting?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the study free from other risks of bias?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
For ITS	
Was the intervention independent of other changes?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the shape of the intervention effect pre-specified?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the intervention unlikely to affect data collection?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was knowledge of the allocated interventions adequately prevented during the study?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Were incomplete outcome data adequately addressed?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	

Was the study free from selective outcome reporting?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the study free from other risks of bias?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Intervention	
Number of treatment arms	(drop-down) 1 – 10
Description of treatment arm 1	
Description of treatment arm 2 (continue adding as needed)	
Type of nutrition intervention	(drop-down – select all that apply) Micronutrient supplementation / Fortification / Education or Counselling / School feeding / Other supplemental nutrition / Other
Description of nutrition intervention	
Type of agency intervention	(drop-down – select all that apply) Mentorship program / Leadership skills training / Technical or occupational skills training / Program leadership role for girls / Peer education / Peer support group / Other
Description of agency intervention	
Type of opportunity structure intervention	(drop-down – select all that apply) Cash transfer program / Savings and loan program / Education support / Girls' rights advocacy or education (with parents, teachers, community influencers) / Prevention of early marriage and pregnancy / Other
Description of opportunity structure intervention	
Intervention setting	(drop-down – select all that apply) School / Community / Home / Health Facility / Other
Other	Describe 'other' intervention setting
Geography	(drop-down – select all that apply) Urban / Rural / Remote / Slum / Other
Other	Describe other geographic setting
Intervention administrator	(drop-down) Foreign government / local or national government / non-government organization / community-based organization / Academic institution / Other
Other	Describe other intervention administrator
Intervention provider	(drop-down – select all that apply) Community health workers / Health facility staff / Teachers / Peers / Parents / Volunteers / Other
Other	Describe other intervention provider
Provider training	Describe the training of providers to deliver intervention
Recruitment	Describe procedures for recruiting participants
Attrition rate	The proportion of participants lost during the intervention or during follow-up.
Reach	Describe the degree to which the intended audience participated in an intervention by 'their presence'
Dose	Describe the proportion or amount of an intervention delivered to participants. E.g., measures of frequency, duration, and/or intensity
Fidelity / integrity	Describe the degree to which the intervention was delivered as intended.
Adaptation	Describe the degree to which the program content was intentionally changed during implementation to improve programme effectiveness

Prior needs assessment	Describe any needs assessment that was conducted to inform intervention design
Reminders	Describe any prompts or reminders sent to participants to attend / participate in intervention
Cost and time	Describe the cost and time required to deliver the intervention
Study population	
Number of participants	
Number in intervention group	
Number in comparison group	
Age range of study participants	Enter age range of study target population, e.g. 15-49 years
Age range of adolescent study participants	Enter age range for female adolescents who are included in study, e.g., 15-24 years
Age sub-groups	List all age sub-groups for which data are provided, e.g. study covers 15-49 years, and analyses were done separately for 15-19 years, 20-24 years, 25-49 years
Did the study population also include men or boys?	(drop-down) Yes / No / Unclear
Adolescent participants' school status	(drop-down) In school / out of school / Both / Unclear
Race / ethnicity / language	Describe
Religion	Describe
Socio-economic status	Describe
Disability, physical health	Describe
Includes pregnant participants	(drop-down) Yes / No / Unclear
Includes young mothers	(drop-down) Yes / No / Unclear
Conflict setting	(drop-down) Yes / No / Unclear
Food insecure setting	(drop-down) Yes / No / Unclear
Outcomes	
Primary outcomes	Define outcomes and how they are measured
Secondary outcomes	Define outcomes and how they are measured
Method of assessing outcomes	Describe methods for assessing outcome measures
Validity and reliability of outcomes measures	Describe primary authors' views on the validity and reliability of outcome measures
Follow-up of non-respondents	Describe the methods used to follow-up non-respondents
Timing of outcome assessment	Describe frequency of assessment, length of follow-up, etc.
Results	
Number of participants in Treatment Arm 1 (continue adding rows for each treatment arm)	
Number of participants in Treatment Arm 2 (continue adding rows for each treatment arm)	
Number of participants in comparison group	
For each outcome…	
Direction of effect	(drop-down) Effect favours treatment / Effect favours comparison / Effect favours neither / Cannot tell

Effect statistically significant?	(drop-down) Yes / No / Cannot tell
Treatment sample size	
Control sample size	
Number of missing participants	
Nature of the measure	(drop-down) Continuous / Dichotomous / Other
If outcome measure is continuous…	
Treatment group mean	
Comparison group mean	
Are reported means adjusted?	(drop-down) Yes / No / Cannot tell
Treatment group standard deviation	
Comparison group standard deviation	
Treatment group standard error	
Comparison group standard error	
t-value for an independent t-test	
If outcome measure is dichotomous…	
Treatment group number of participants who experienced a change	
Comparison group number of participants who experienced a change	
Treatment group proportion of participants who experienced a change	
Comparison group proportion of participants who experienced a change	
Are the proportions adjusted for pretest variables?	
Logged odds ratio	
Standard error of logged odds ratio	
Adjusted logged odds ratio	
Chi-square with degrees of freedom	
Correlation coefficient	
Adverse events	
Adverse events	List all adverse events of integrating women's empowerment, as described by primary authors.

Appendix D. Qualitative Study Codebook

Code	Description
Study ID	from Covidence
Date coded	
Coder initials	
Correspondence required	Add a note here if authors will need to be contacted to request additional information
Reference identification	
Title	
First author	
Year	
Type of publication	(drop-down) Journal article / Book / Conference abstract / Dissertation / Report / Other
Other	Define 'other' publication type
Funder	
Country	
City and region (if applicable)	
Start date of study	
End date of study	
Aim of the study	
Authors' definition of empowerment	
Authors' rationale for empowerment approach	
Methods	
Study design description	
Study duration	
Participant inclusion/exclusion criteria	
Quality assessment (CASP)	
Was there a clear statement of the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Is a qualitative methodology appropriate?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the research design appropriate to address the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the recruitment strategy appropriate to the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the data collected in a way that addressed the research issue?	(drop-down) Yes / No / Unclear

Support for judgement (incl. pg #)	
Has the relationship between researcher and participants been adequately considered?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Have ethical issues been taken into consideration?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the data analysis sufficiently rigorous?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Is there a clear statement of findings?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
How valuable is the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Study population	
Number of participants	
Study scale	Small (e.g., one/several village) / large (e.g., district, region, province)
Describe scale	
Study setting	(drop-down) Urban / Rural / Informal-urban / Remote / Other
Describe setting	
Target	(drop-down) Individual / Household / Community / Other
Describe target	
Age range of study participants	Enter age range of study target population, e.g. 15-49 years
Adolescent age range	Enter age range for female adolescents who are included in study, e.g., 15-24 years
Age sub-groups	List all female age sub-groups for which data are provided, e.g. study covers 15-49 years, and analyses were done separately for 15-19 years, 20-24 years, 25-49 years
Did the study population also include men or boys?	(drop-down) Yes / No / Unclear
Adolescent participants' school status	(drop-down) In school / out of school / Both / Unclear
Race / ethnicity / language	Describe
Religion	Describe
Socio-economic status	Describe
Disability, physical health	Describe
Includes pregnant participants	(drop-down) Yes / No / Unclear
Includes young mothers	(drop-down) Yes / No / Unclear
Conflict setting	(drop-down) Yes / No / Unclear
Food insecure setting	(drop-down) Yes / No / Unclear
Intervention	
Type of nutrition intervention	(drop-down – select all that apply) Micronutrient supplementation / Fortification / Education or Counselling / School feeding / Other supplemental nutrition / Other
Description of nutrition intervention	

Type of agency intervention	(drop-down – select all that apply) Mentorship program / Leadership skills training / Technical or occupational skills training / Program leadership role for girls / Peer education / Peer support group / Other
Description of agency intervention	
Type of opportunity structure intervention	(drop-down – select all that apply) Cash transfer program / Savings and loan program / Education support / Girls' rights advocacy or education (with parents, teachers, community influencers) / Prevention of early marriage and pregnancy / Other
Description of opportunity structure intervention	
Intervention setting	(drop-down – select all that apply) School / Community / Home / Health Facility / Other
Describe intervention setting	
Intervention administrator	(drop-down) Foreign government / local or national government / non-government organization / community-based organization / Academic institution / Other
Describe intervention administrator	
Intervention provider	(drop-down – select all that apply) Community health workers / Health facility staff / Teachers / Peers / Parents / Volunteers / Other
Describe intervention provider	
Provider training	Describe the training of providers to deliver intervention
Recruitment	Describe procedures for recruiting participants
Attrition rate	The proportion of participants lost during the intervention or during follow-up.
Reach	Describe the degree to which the intended audience participated in an intervention by 'their presence'
Dose	Describe the proportion or amount of an intervention delivered to participants. E.g., measures of frequency, duration, and/or intensity
Fidelity / integrity	Describe the degree to which the intervention was delivered as intended.
Adaptation	Describe the degree to which the program content was intentionally changed during implementation to improve programme effectiveness
Prior needs assessment	Describe any needs assessment that was conducted to inform intervention design
Reminders	Describe any prompts or reminders sent to participants to attend / participate in intervention
Cost and time	Describe the cost and time required to deliver the intervention
Measures	
Feasibility (the extent to which an intervention is practical or viable in a particular context or situation)	
Cultural sensitivity of program	
Participant engagement	
Community/public commitment	
Appropriateness (the extent to which an intervention or activity fits with a particular context or situation)	
Participants' views on programme acceptability	
Implementers' views on programme acceptability	
Community support for programme	

Meaningfulness (the extent to which an intervention or activity is positively experienced by an individual or group)	
Participants' views on programme as a positive or negative experience	
Participants' views on benefits and costs of participation	
Participants' awareness of own nutritional needs	
Participants' motivation to act for improved nutrition	
Community desire to support participants to act for improved nutrition	
Adverse events	
Adverse events	List all adverse events of integrating women's empowerment, as described by primary authors.

3.2 REVIEW: The effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries

This section presents the findings of a mixed-methods systematic review of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries, of which the protocol was presented in Section 3.1. The review consisted of screening more than 23,000 records to identify eligible studies and their companion articles. In the end, ten studies were included in the effectiveness review and two reports assessing implementation and contextual factors influencing intervention effectiveness. Study quality varied significantly across the studies. Several important gaps in the evidence base and opportunities for future research were identified. The logic model presented in the protocol was revised based on the review's findings, providing an evidence-based framework for the design and evaluation of empowerment-based nutrition interventions for adolescent girls in LMICs.

Manuscript status

The manuscript is submitted to *Campbell Systematic Reviews*.

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Authors' roles and contributions

AYR, GW, VW conceived the study. BS designed the search strategy. AYR, OM, AR, FJ, SM conducted screening, data extraction and quality assessments. AYR conducted the syntheses and drafted the report, which was revised by all authors. All authors approved the version of the manuscript submitted for publication.

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REVIEW: The effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries

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Plain language summary

The review in brief

There is no clear evidence that empowerment-based nutrition interventions for adolescent girls in low- and middle-income countries improves their weight, body mass index (BMI), waist circumference, haemoglobin, anemia risk, total dietary intake, or self-efficacy.

What is this review about?

Proper nutrition is crucial for adolescent health and development, yet many adolescent girls in low- and middle-income countries (LMICs) are malnourished. Unequal access to food, education, and health services due to gender discrimination exacerbate this problem. Empowering adolescent girls as part of nutrition programmes may lead to improvements in their nutritional status by helping to combat gender inequities. For the purposes of this review, empowerment-based nutrition interventions seek to improve adolescent girls' dietary intake while also fostering their agency over their own health and nutrition and creating a supportive environment. This review looked at the impact of these interventions on measures of adolescent girls' nutritional status, including their weight, body mass index, waist circumference, haemoglobin, anemia risk, and total dietary intake.

What is the aim of this review?

The primary objective of this Campbell systematic review was to answer two questions: (1) What is the effect of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries? (2) What are the implementation and contextual factors influencing the success or failure of these interventions? To answer the first question, the review summarizes evidence from ten studies, including four randomized controlled trials and six non-randomized studies. To answer the second question, one quantitative study and one qualitative study were included.

What are the main findings of this review?

What studies are included?

A total of ten studies assessing the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs were included. Eight of the studies were conducted in middle-income countries and focused on preventing or treating overweight and obesity among adolescent girls. One study was conducted in Benin, one study in India, two studies in Brazil, and six studies in Iran. All studies were conducted in a school setting. Most studies had important methodological weaknesses. Two studies assessing implementation and contextual factors were identified.

Do empowerment-based nutrition interventions improve the nutritional status of adolescent girls in LMICs?

It is unclear. There is limited, low-quality evidence of the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs. Empowerment-based nutrition interventions may reduce BMI, waist circumference, the risk of anemia and total dietary intake, but the evidence is very uncertain. Similarly, empowerment-based nutrition interventions may increase haemoglobin, total dietary intake, and self-efficacy, but the evidence is very uncertain.

What are the implementation and contextual factors influencing the success or failure of these interventions?

Implementation factors that may contribute to intervention success include adapting the intervention to the local context and culture, training intervention providers, ensuring adequate availability of personnel, facilities, and materials, providing material incentives to adolescent girls to encourage participation, tailoring the intervention content to the education level of the participants, and pilot testing the intervention. Contextual factors that may affect intervention success are the socio-economic status of the community, food availability, and general insecurity.

What do the findings of this review mean?

Evidence of the effectiveness of empowerment-based nutrition interventions to improve the nutritional status of adolescent girls in LMICs is inconclusive and warrants further investigation. This includes conducting studies in a variety of settings (e.g., low-income countries, non-school settings) and using robust, high quality study designs. Further study of the implementation and contextual factors that contribute to intervention success is needed.

How up to date is this review?

The review authors searched for studies up to 2021.

Abstract

Background

Proper nutrition during adolescence is crucial for optimal growth and development and helps to prepare adolescents for adulthood, yet proper nutrition is out of reach for many. Adolescent girls in low- and middle-income countries (LMICs) are disproportionately affected by poor nutrition due to biological and social factors, including gender inequities. Empowering adolescent girls may contribute to improving their nutritional status in settings where gender inequality persists.

Objectives

The primary objective of the review was to answer two questions: (RQ1) What is the effect of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries? (RQ2) What are the implementation and contextual factors influencing the success or failure of these interventions?

Search methods

This review applied a segregated mixed methods research synthesis design (MMRS). A comprehensive search strategy was developed with the assistance of an information specialist. Databases were searched up to Sept. 2021 included Ovid MEDLINE®, Embase, PsycINFO, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and CINAHL. Grey literature and handsearching were conducted up to 2023.

Selection criteria

The review target population was adolescent girls (10-19y) residing in LMICs. For RQ1, eligible interventions were empowerment-based nutrition interventions to improve dietary intake, defined by the review's logic model. Eligible study designs were randomized and non-randomized studies with at least one comparison group. The primary outcome of interest was nutritional status (e.g., BMI). For RQ2, eligible studies were quantitative or qualitative study designs that assessed the implementation or contextual factors of studies included in RQ1.

Data collection and analysis

Study selection, data extraction and quality assessments were conducted in duplicate by two independent reviewers. Quantitative data were synthesised using random effects meta-analysis or narrative synthesis. The "best-fit" framework synthesis method was used to synthesize qualitative findings.

Main results

(RQ1) Four randomized controlled trials and six non-randomized studies were included. The review found limited, low-quality evidence that empowerment-based nutrition interventions may lead to little/no improvement in adolescent girls' body mass index, waist circumference, haemoglobin, anemia risk, and total dietary intake. The existing evidence base is largely limited to interventions to prevent or treat obesity among adolescent girls in middle-income countries. (RQ2) One qualitative study and one quantitative study were included. Implementation factors that may contribute to intervention success include adapting the intervention to the local context and culture, training intervention providers, ensuring adequate availability of personnel, facilities, and materials, providing material incentives to adolescent girls to encourage participation, tailoring content to the education level of the participants, and pilot testing the intervention. Contextual factors that may affect intervention success are the socio-economic status of the community, food availability, and general insecurity. The review's logic model was revised to incorporate findings from RQ1 and RQ2.

Author's conclusions

The evidence on empowerment-based nutrition interventions to improve the nutritional status of adolescent girls in LMICs is inconclusive and warrants further investigation. Future research should include assessments of interventions in low-income countries where undernutrition remains prominent and in non-school settings. Study quality needs to be improved with careful attention to managing selection bias and confounding, blinding assessors and analyses, and transparent outcome and analysis reporting. Further study of the implementation and contextual factors that contribute to intervention success is needed.

Background

The problem, condition, or issue

Adolescents (10 to 19 years) currently represent the largest global generation of young people in our collective history [1]. The regions of Africa, Asia, Latin America, and the Caribbean are the home of 1.1 billion young persons [2]. In sub-Saharan Africa, people below the age of 25 make up 62% of the population, with only marginal declines predicted through 2050 [3]. The working age population (25 to 64 years) in sub-Saharan Africa, Oceania, and parts of Asia, Latin America, and the Caribbean is growing faster than all other age groups [3]. Ensuring the health and well-being of adolescents who will fill the ranks of the world's working age population will help to propel global economic growth and development [4].

Adolescence is a period of significant physiological change that includes marked skeletal growth, increased bone mass, and fundamental neurological development [4,5]. Proper nutrition during adolescence is crucial for optimal growth and development and helps to prepare adolescents for adulthood. However, many adolescents face challenges in achieving optimal dietary intake, especially in low- and middle-income countries (LMICs) where most adolescents reside [6]. Iron-deficiency anemia affects 430.7 million (24%) adolescents, with 77% of adolescents living with anaemia in multi-burden countries where communicable, maternal, and nutritional conditions contribute to 2,500 disability adjusted life years (DALYs) or more per 100,000 adolescents [7]. The prevalence of anaemia is consistently higher for females than males, and is more than 50% for females in Bhutan, Yemen, India, and Burkina Faso in 2016 [7]. Mean BMI (body mass index) and the prevalence of obesity are also rising among children and adolescents globally. The percentage of adolescents who are overweight or obese was 324.1 million in 2016—an increase of 176.9 million from 1990 [7]. The median prevalence of overweight and obesity among girls is highest in the Eastern Mediterranean region (28%), followed by the Western Pacific (25%), the Americas (25%), and Europe (21%). [8]. Yet more children and adolescents are moderately or severely underweight globally, with the largest burden of underweight found in South Asia and central, east and west Africa [9].

The social, economic, and cultural conditions in which an adolescent matures can significantly shape their health and development, including their nutrition. The social determinants of health are the conditions in which people are born, grow, develop, live, work, and age [10]. Social inequities, particularly those related to poverty and gender, can heavily influence adolescent health and well-being [4]. Adolescence is a time when gender roles and norms become more heavily engrained, affecting how adolescents interact with and experience the world. The gendered experience of adolescence can vary depending on the

context, as Kabeer writes: “In many LMICs, the gendered norms embedded in local structures of patriarchy come into play in heightened ways during adolescence, restricting the agency, opportunities, aspirations and social networks of young girls to a far greater extent than boys” [11]. Where considerable gender inequities exist, women and girls are more likely to suffer from nutritional deficiencies than men and boys [12]. Gender inequities can limit access to an adequate diet and lead to early marriage and high fertility rates, putting adolescent girls at greater risk of nutrient deficiencies as well as poor pregnancy and birth outcomes [8,13]. Numerous studies have identified a significant association between women’s empowerment and women’s and children’s nutritional status, but relatively few have examined the specific case of adolescent girls [14–19].

The intervention

The empowerment of women and girls has been identified as way of improving the nutrition sensitivity of interventions, in addition to achieving scale and increased coverage of at-risk households and individuals [20]. There is growing interest in assessing the impact of empowerment interventions on women’s empowerment as well as its instrumental value in improving development outcomes, including women’s and children’s health and nutrition. The objective of this is review is to build on the existing evidence base to examine the effects of integrating empowerment strategies in nutrition interventions to improve the nutritional status of adolescent girls in low- and middle-income countries.

Defining empowerment and its related components

There are various definitions of women’s empowerment, illustrating the complexity of the construct [21–26]. A commonly used definition is that of Naila Kabeer. She defines empowerment as “the expansion in people’s ability to make strategic life choices in a context where this ability was previously denied to them” [22]. Kabeer identifies three interdependent components to women’s empowerment. The first is agency, or “the ability to define one’s goals and act upon them.” Alsop and Heinsohn (2005) define agency as “the ability to make meaningful choices.” Similarly, Sen describes agency as “what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important” [27] Central to these definitions is (a) the availability of alternatives from which to choose, (b) the individual is aware of the alternatives available to them and (c) the individual desires to make a choice [21,22]. Agency is often described in terms of decision-making power, but it can also reflect an ability to bargain, negotiate, influence, resist, or manipulate [28].

Kabeer (2001) identifies the second component of empowerment, resources, as a precondition for the ability to exercise choice (agency). Resources can be material, human or social. Alsop and Heinsohn (2005) refer to this component as opportunity structure, or “the formal and informal contexts within

which actors operate." We will use the term "opportunity structure" to represent this second component for the purposes of this review. A supportive opportunity structure will enable an individual to make their choices a reality. For example, an adolescent girl may desire to stay in school until graduation, but she may be prevented from doing so if her parents are not supportive.

The final component is achievements. Agency and opportunity structure interact to result in the achievement of an individual's desired outcomes. Sen (1985) refers to this interaction as capabilities, or the potential that people have for living the lives they want. Notably, chosen actions that lead to undesired outcomes do not signify a high degree of empowerment. For example, the decision to participate in a microcredit programme may increase a married adolescent girl's access to financial resources, but if her husband controls how those resources are spent, the desired outcome of financial autonomy would not be achieved.

Empowerment can take place in different dimensions of girls' lives. A high degree of empowerment in one area does not automatically translate into empowerment in other areas. For instance, an adolescent girl may be able to attend school (an indicator of social empowerment) but she may be denied the right to access health care without her guardian's permission (an indicator of household or intrafamilial empowerment). We have adopted six conceptual definitions of empowerment developed by Malhotra and colleagues [25].

- Economic empowerment reflects access and claims to material resources, such as control over one's income.
- Political empowerment is the ability to be included in political processes and to self organise. For example, the ability to organise and participate in a community group.
- Legal empowerment is the reflection of women's and girls' rights as codified in law, such as the right to an education or the right to vote.
- Socio-cultural empowerment reflects the type and quality of relationships with other people and groups outside of the household, often highly influenced by society' gender norms. Examples include women's and girls' freedom of movement and society's commitment to girls' education.
- Intrafamilial empowerment affects the social hierarchy and dynamics within the household, such as influence in household decision-making or decisions related to one's own health, education, etc.
- Psychological empowerment is an individual's belief that they can achieve their goals. An example is an individual's perception of their own self efficacy. This dimension is closely related to the concept of agency.

The gender equality challenges, and the relevance of different empowerment dimensions, will vary by context. For example, sociocultural norms in South Asia can restrict women's ability to leave home without a male relative or chaperone. In sub-Saharan Africa, migrant labour among men is common, giving women greater levels of independence, if not actual autonomy.

Operationalizing empowerment

The operationalization of empowerment in health and development programmes has largely focused on improving access to resources, assets, and services for adult women. Interventions that have been assessed include women's self-help groups [11,29–32], cash transfer programmes [33–37], microcredit programmes [31,38–42], agriculture programmes [43,44], and programmes to strengthen inheritance and property rights [45,46].

Shankar, Sundar, and Smith (2019) have written about the gap in focusing specifically on agency-based interventions, that include "designing spaces that allow individuals to self-define their goals in life areas such as work, relationships, sexuality, spirituality, or financial security" [47]. Similarly, Cornwall has highlighted the neglect of building "critical consciousness" as part of women's empowerment interventions in favour of a focus on resources [48]. As such, we will build on their work by assessing the effectiveness of nutrition interventions that include activities to foster agency as well as creating a supportive opportunity structure (including access to resources) as a way to empower adolescent girls and improve their nutritional status.

Empowerment-based nutrition interventions

This review will summarise the evidence concerning the effectiveness of empowerment-based nutrition interventions for adolescent girls in low- and middle-income countries. In other words, we will assess the effectives of nutrition interventions that include activities to (a) foster adolescent girls' agency and (b) create a supportive opportunity structure for adolescent girls' empowerment. For the purposes of this review, we define nutrition interventions as interventions intended to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation[49]. Examples of eligible nutrition interventions are micronutrient supplementation (iron, folic acid, vitamins A, D, etc.), food supplementation programmes (e.g., school feeding), and nutrition education or counselling.

To be empowerment-based, the intervention must include activities to support adolescent girls' agency and activities to create a supportive opportunity structure for adolescent girls' empowerment. An intervention that fosters agency will include activities designed to increase adolescent girls' motivations

and abilities to make informed decisions by providing spaces for self-reflection and identification of important life areas [47]. Such interventions enable adolescent girls' active and meaningful participation in decision-making, instil a sense of self-efficacy, and increase self-esteem and motivation to make a positive change in pursuit of strategic life goals. Examples of activities that foster agency are life skills training programmes, mentorship programmes, counselling programmes, and other programmes that create "safe spaces" for adolescent girls or equip adolescent girls to make informed strategic life decisions. Interventions can be delivered one-on-one or in a group setting and can take place in a variety of settings include at home, at school and in the community.

The intervention must also include activities to build a supportive opportunity structure. Such activities aim to alter the constraining political, economic, socio-cultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency [21,25]. This includes access to and control over resources. The type of activities that are undertaken to create a supportive opportunity structure will vary by context, thus we cannot provide an exhaustive list. Instead, we opted to categorize activities by type according to the dimension of empowerment they seek to redress. For example:

- Economic dimension: Economic activities aim to increase adolescent girls' access to and control over financial and material resources. These include microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.
- Socio-cultural dimension: Socio-cultural activities aim to redress discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intrahousehold food discrimination, and programmes to support adolescent girls' completion of secondary education.
- Legal dimension: Legal activities aim to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights. This can include adolescent girls' rights to education, family planning, employment, or inheritance.

Table 1 provides examples of how the three different intervention components can combine to create an eligible intervention study. Each intervention must have as its main activity a nutrition intervention aimed to improve dietary intake among adolescent girls as well as include agency-related activities and opportunity structure activities.

Table 1. Examples of empowerment-based nutrition interventions by intervention component.

Study	Nutrition component	Agency component	OS component
Study 1	Nutrition education sessions	Individual nutrition counselling and motivational support	Intrafamilial: Nutrition education session for parents
Study 2	Iron and folic acid supplementation	Financial skills training	Economic: Opening a savings account
Study 3	School lunch program to improve dietary iron intake	Peer-led support group to support health food choices	Sociocultural: Community engagement to improve school menus

How the intervention might work

We hypothesise that including empowerment-related activities in a nutrition intervention will mediate the impact of underlying gender inequities that contribute to poorer health outcomes for adolescent girls and will result in greater nutritional gains compared with programmes that do not promote empowerment.

Our logic model is presented in Figure 1. The logic model depicts the causal pathways from the implementation of an empowerment-based nutrition intervention to improved nutrition outcomes for adolescent girls. The development of the logic model was informed by a review of existing models and conceptual frameworks on nutrition [49–52] and empowerment [21,25,28,30,37,53,54].

The model begins with the proposed three elements of an empowerment-based nutrition intervention:

- Activities to improve dietary intake
- Activities to foster agency
- Activities to build a supportive opportunity structure

In the short term, the elements are hypothesised to lead to an expansion in an adolescent girl's awareness of the choices available to her to improve her nutritional status, and to increase her motivation to act. The nutrition-related activities will improve her awareness, knowledge, and skills for the adoption of a healthy diet and positive health behaviours. The agency-related activities complement the nutrition-related knowledge she has acquired to increase her awareness and motivation to make an informed choice to improve her health and nutrition. A supportive opportunity structure will enable her to move toward action based on her choices. For example, a school-based micronutrient supplementation programme for adolescent girls that includes a peer support programme to build girls' nutrition-related knowledge and self-confidence (agency) and a sensitisation programme for parents and teachers to the importance of supplementation for adolescent girls (opportunity structure) will increase a girl's knowledge of the importance of supplementation for her health and well-being, increase her motivation to participate in the

supplementation programme, and create an enabling environment that will provide the necessary resources and supports for her to participate in the programme.

In the intermediate term, the intervention is expected to empower adolescent girls by increasing their decision-making power, improving their access to and control over resources (human, capital, social), and contribute to the protection and promotion of their human rights, such as the right to health care, education, freedom of movement, freedom from violence so forth. Returning to our illustrative example, an adolescent girl will have more decision-making power because she has acquired the information that she needs to make an informed decision, she has the confidence to decide, and she has the support from parents and teachers to enable her decision-making. Her access to resources is also improved with the support of the adults in her life. Finally, the sensitisation of parents and teachers helps to prevent any potential restrictions on her rights that may impede her ability to participate in the programme.

Moving along the results chain, the empowerment-related outcomes are hypothesised to feed into improved health and nutrition behaviours, improved access to a nutritious diet, and improved access to essential health services. In the case of our example, an intermediate outcome would be adolescent girls taking micronutrient supplements consistently because they have decided it is important to them, and their environment supports them to do so. In the longer term, the intervention would lead to improved dietary intake and improved nutritional status.

The exact causal pathways will vary depending on the intervention design which should be informed by the context and the particular gender-related barriers present. While we have focused this systematic review on interventions to improve dietary intake, the logic model includes pathways to improved nutritional status via improved access to essential health services for the prevention of diseases that contribute to malnutrition (e.g., malaria) and the prevention of an early unwanted pregnancy—a significant contributor to malnutrition among adolescent girls [50].

Promoting girls' empowerment can also potentially lead to adverse effects. For example, adolescent girls, empowered to choose their own diets, may opt to consume calorie-dense but nutrient-poor foods, such as sugar-sweetened beverages [8]. There may also be backlash within the household or community in response to adolescent girls' attempts to assert increased autonomy, which may be perceived as threatening traditional power structures. Capturing the adverse effects of the intervention is a critical component to be explored that will assist in intervention design that maximises benefits and minimises harms.

Underpinning the logic model are the individual-level, household, community, and macro-level factors that can moderate the expected outcomes along the causal pathway. At the individual level, socially

stratifying factors that contribute to health inequities have the potential to place additional barriers to proper nutrition for adolescent girls and need to be considered in intervention design and evaluation. The PROGRESS-Plus framework [55] is a useful pneumonic summarising these factors: Place of residence, Race/ethnicity/culture/language, Occupation, Gender/sex, Religion, Education, Socioeconomic status, and Social capital. The "Plus" stands for other personal characteristics (e.g., age or disability), features of relationships (e.g., children of parents who smoke), and time-dependent relationships (e.g., recently out of hospital) that can make an individual more vulnerable to poor health. Household and community characteristics can affect intervention effectiveness as well. Things to consider include household food security and water and sanitation facilities, the availability of health services in the community, women's representation in community leadership or other governing bodies, and other community gender norms, such as son preference. Finally, consideration of the macro-level context includes such things as the national or regional food environment and food security, and national gender-related laws, policies, and institutional practices. The exact strategies necessary to foster agency and opportunity structure are highly context-specific and point to the importance of understanding not only how women's empowerment affects nutrition outcomes, but also how these contextual factors influence intervention effectiveness.

A final element to consider are the implementation factors regarding the intervention itself (Cargo et al., 2018). These include the intervention setting and delivery platform (e.g., school, health facility, community, etc.), the intervention provider (e.g., teacher, community leader, facility-based health worker, community health worker, etc.), how participants were recruited, participant retention strategies and attrition rates, the reach and dose of the intervention, fidelity to intervention design, and the adaptability of the intervention to the local context and circumstances.

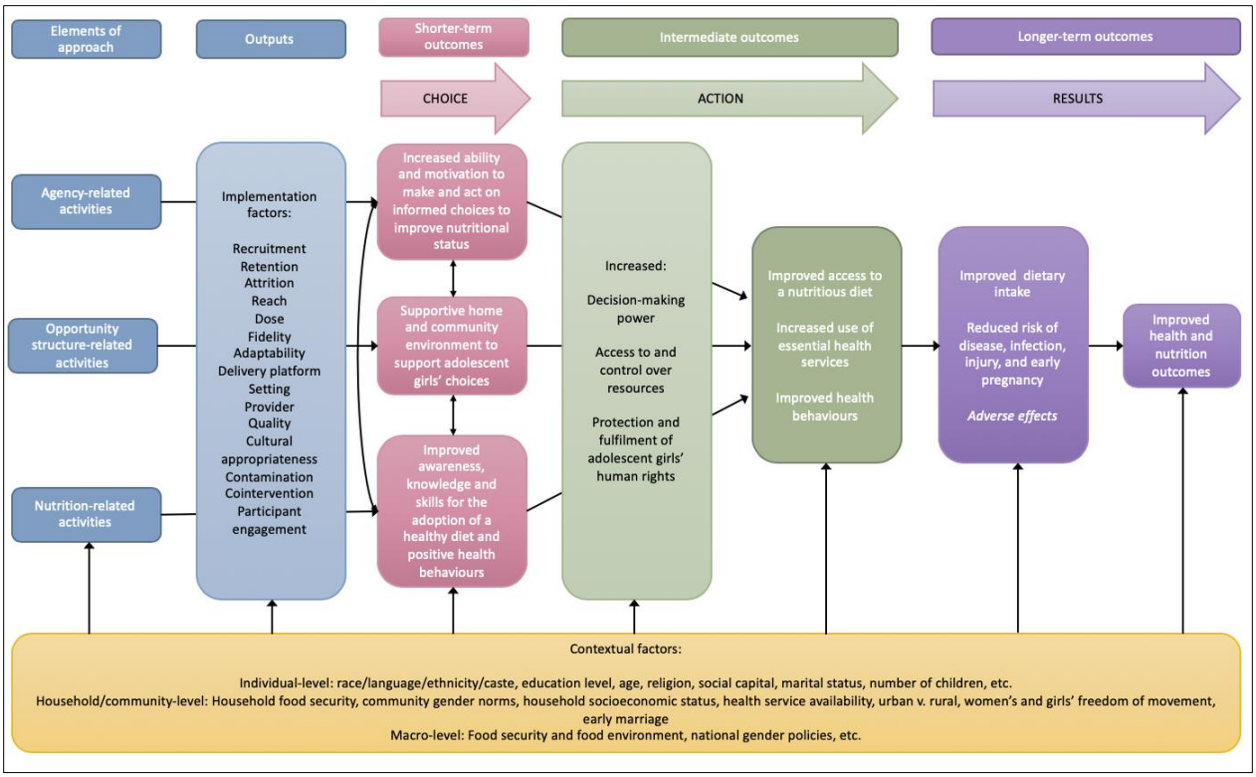


Figure 1. Logical model of the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status.

Why it is important to do this review

There is a rapidly expanding body of literature on women's empowerment and health, including nutrition, which offers valuable evidence that the empowerment–nutrition link is important to understand. Below we summarise existing reviews of interventions related to women's empowerment and nutrition in low- and middle-income countries. Our systematic review will expand on this evidence base by: (a) focusing on the role of empowerment in adolescent girls' nutrition (an understudied population), (b) attempting to separate out the role of agency-related and opportunity structure-related activities in the empowerment process, and (c) systematically reviewing and synthesising the evidence on the contextual and implementation factors that may help to explain the success or failure of empowerment-based nutrition interventions.

Reviews

Van den Bold, Quisumbing, and Gillespie (2015) conducted a review of nutrition-sensitive structural interventions (cash transfer, agriculture, and microcredit programmes) to assess their impact on women's empowerment and infant and child nutrition, and found that, despite the existence of considerable evidence depicting the associations between women's empowerment and nutritional status, more research

is needed to understand the pathways that connect the two concepts. The review did not examine outcomes for adolescent girls.

Similarly, Taukobong et al. (2016) reviewed the literature across six sectors, including nutrition, to assess whether addressing gender inequalities and empowering women and girls improves health and development outcomes. They identified common gender equality and women's empowerment variables that repeatedly emerged as significant predictors of sector outcomes, including control over income, decision-making power, and education, but also identified the need for more research into mechanisms through which gendered interventions might work. The review did not examine outcomes for adolescent girls.

Brody et al. (2015) conducted a systematic review of economic self-help group programmes for improving women's empowerment. They concluded that self-help groups have positive effects on women's economic, social, and political empowerment. Qualitative findings indicated that the poorest women were less likely to participate due to time constraints and fears of racial or caste discrimination. The review did not assess the impact of economic self-help groups on health or nutrition outcomes for adolescent girls.

Kumar et al. (2018) conducted a review of women's group-based programmes and nutritional change in South Asia. They mapped interventions to four conceptual pathways (income, agriculture, health and nutrition behaviour change, and rights) from women's groups to improved nutritional status among women and children. They found the strongest evidence linking the behavior change pathways to improved nutritional status, but also noted a number of challenges in assessing the evidence based including the lack of rigorous studies, difficulties in disentangling the effects of group-based activities with other aspects of the intervention, a paucity of studies targeting nutritionally vulnerable age groups, and programmes with insufficient reach and duration. They recommend that implementers and evaluators identify a priori which change pathways they anticipate to activate and measure processes and impacts accordingly. The review did not examine interventions or outcomes for adolescent girls.

Brandstetter, Rüter, Curbach, and Loss (2015) conducted a systematic review of the various ways of applying the empowerment concept to healthy nutrition in health promotion. The included eight studies that were all based in high-income countries. They found diversity in the way the concept of empowerment was operationalized, in the integration of other theoretical frameworks (e.g., socio-cognitive theory), and reporting in the methods of operationalizing and measuring empowerment.

The WHO Guideline, "Implementing effective actions for improving adolescent nutrition" (WHO, 2018a), summarises the global evidence for addressing malnutrition in adolescents. The guideline

identifies implementing interventions to empower adolescent girls may prevent early marriage and pregnancy, reduce sexual coercion, and notes that community stakeholders (including teachers and health workers) need to support the empowerment of adolescents to adopt and maintain optimal nutrition and health practices. The guideline further identifies as a research gap the assessment of impact of interventions and policies on autonomy, positive development, empowerment, and engagement of adolescents.

Systematic reviews of adolescent nutrition interventions (Bhutta et al., 2013; Lassi, Moin, Das, Salam, & Bhutta, 2017; Salam, Hooda, et al., 2016) have also shed valuable light on the effectiveness of nutrition interventions in improving adolescent health, but they have not specifically assessed the role of empowerment in adolescent health and nutrition.

Protocols

Vollmer et al. (2017) have published a protocol for a systematic review of the effect of women's economic empowerment on children's health and education.

Objectives

The primary objective of the review was to answer the following two questions:

1. What is the effect of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries?
2. What are the implementation and contextual factors influencing the success or failure of these interventions?

In addition, we sought to answer the following questions as secondary objectives:

3. What are the underlying empowerment-related programme theories applied to intervention design? How is empowerment defined, operationalized, and measured?
4. What is the effect of empowerment-based nutrition interventions on the empowerment of adolescent girls?
5. What are the potential adverse effects of an empowerment-based approach on adolescent girls' health and well-being?

Methodology

This review applied a segregated mixed methods research synthesis design (MMRS). MMRS combines qualitative, quantitative, and mixed method primary-level studies and applies a mixed methods approach to synthesise and integrate the studies' results [56]. This design is more appropriate for the study of

interventions that consist of multiple components as it helps to better understand how the different components are related and interact with each other [57].

Through a comprehensive literature search, we identified relevant literature with qualitative and quantitative study designs that were segregated at the screening phase. Qualitative and quantitative studies were analysed and synthesised separately, while the implications for practice, policy, and research that form the discussion and conclusion sections of the review draw on both the qualitative and quantitative syntheses.

Criteria for including and excluding studies

Study design

To answer RQ1, we included the following study designs:

- Randomised Controlled Trials (RCTs), including cluster randomized trials
- Controlled before and after studies (CBAs)

We did not identify any studies that met our inclusion criteria using the following designs:

- (Controlled) interrupted time series (CITS, ITS)
- Propensity score matching (PSM) on baseline covariates
- Regression discontinuity design (RDD)
- Difference in difference using regression techniques (DID)
- Interventions with a synthetic control group
- Other quasi-experimental designs with at least one comparison group

Studies without an observable comparator or credible means for controlling for selection bias were excluded.

To answer RQ2, we included companion quantitative and qualitative studies that assessed the contextual and implementation factors influencing the effectiveness of the studies included in our effectiveness assessment (RQ1). We included qualitative studies that explored the perspectives of intervention participants (adolescent girls), providers (those who delivered the intervention), or administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors contributing to intervention success or failure using focus groups, in-depth interviews, or participant observation. Eligible qualitative study designs included case studies, ethnographic research, grounded theory, and other thematic approaches to qualitative data analysis. Qualitative studies that did not report clear methods and results sections were excluded. This included opinion pieces and editorials. Eligible

quantitative studies applied quantitative methods to assess the influence of implementation or contextual factors on intervention effectiveness, such as through survey, descriptive or correlational research.

Types of participants

The review target population was adolescent girls (10 to 19 years) residing in low- and middle-income countries, regardless of health status. The classification of countries as low- or middle-income was based on the World Bank income groups as defined at the time the studies were conducted. Studies undertaken in high-income countries were excluded.

Types of interventions

Eligible studies were empowerment-based nutrition interventions to improve dietary intake among adolescent girls. More specifically, we included interventions whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation. Examples of eligible nutrition interventions included:

- Micronutrient supplementation or fortification interventions (iron, folic acid, iron–folic acid (IFA), calcium, vitamin D, vitamin A, zinc, iodine, and multiple micronutrients)
- Nutrition education or counselling interventions, and
- Supplementary nutrition programmes such as school feeding.

To be considered "empowerment-based," the nutrition intervention had to include one or more activities intended to foster adolescent girls' agency, and one or more activities to create a support opportunity structure for adolescent girls' empowerment. We defined activities to foster agency as those that "provide spaces for self-reflection and identification of important life areas" [47] and equip adolescent girls to make informed strategic life decisions. Examples of activities that foster adolescent girls' agency that we searched for included, but were not limited to:

- Counselling programmes (individual or group)
- Mentorship programmes (including peer mentorship)
- Leadership training
- Life skills training
- Technical or occupational skills training

These programmes could be delivered one-on-one (e.g., individual mentorship or counselling) or in a group setting such as girls' clubs or other peer support or participatory action groups.

We defined activities to create a supportive opportunity structure as those that aim to alter the constraining political, economic, sociocultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency [21,25]. Examples of opportunity structure activities by empowerment dimension include, but were not limited to:

Economic: Activities aimed at increasing adolescent girls' access to and control over financial and material resources, such as microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.

Socio-cultural: Activities aimed at redressing discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intra-household food discrimination, or programmes to support adolescent girls' completion of secondary education.

Legal: Activities to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights, such as the right to education, family planning, employment or inheritance.

Nutrition-sensitive interventions, such as water, sanitation, and hygiene (WASH) programmes, agriculture programmes including community gardens, cash transfer programmes, food security programmes, and family planning programmes were considered eligible for inclusion if they served as a delivery platform for an intervention whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted.

Comparison

Studies that had a clearly defined comparison group for evaluation of the treatment effect were included.

Types of outcome measures

Primary outcomes for RQ1 were measures of adolescent girls' nutritional status, including:

- Body mass index (BMI), BMI-for-age, or BMI-for-age z-score
- Haemoglobin, serum ferritin, or anemia status
- Waist circumference
- Arm circumference

RQ2 secondary outcomes were:

- Dietary intake, including micronutrient intake
- Access to a nutritious diet
- Health behaviours
- Access or use of essential health services

We included studies that reported at least one outcome for our population of interest.

To answer RQ2, our outcomes of interest were the perspectives of intervention participants (adolescent girls), providers (those who delivered the intervention), and administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors that affected intervention success or failure. These data could be qualitative, in the form of in-depth interviews, focus groups, or participant observation, or quantitative such as quantitative survey results or correlations between implementation/contextual factors and effectiveness outcomes of interest (RQ1).

To answer RQ3, we extracted details on the empowerment-related theories, as described by primary study authors, that were used to inform the development of the empowerment-related activities (i.e., agency-related and opportunity structure-related activities). Further, we extracted information on the activities that primary authors describe as adolescent empowerment and the primary authors' rationale for adopting specific empowerment-related activities.

For RQ4, we extracted measures of adolescent girls' empowerment. We intended to classify and analyze measures according to the empowerment dimensions listed above, but only one empowerment measure was identified in the review.

Finally, to answer RQ5, we extracted measures of the negative or adverse effects of the intervention on adolescent girls' health or well-being.

Duration of follow-up

We included studies of any follow-up duration and planned to conduct sensitivity analyses by length of follow-up to test the sustainability of treatment effect, but there was an insufficient number of included studies to conduct sensitivity analyses.

Types of settings

Any intervention setting was eligible, including the home, community, school, workplace, or health facility.

Language

No language restrictions were applied.

Publication date

No publication date restrictions were applied.

Search strategy

A comprehensive search strategy was developed with the assistance of an information specialist (Appendix A). Keywords used to develop the search strategy include variations on the following: "power," "empowerment," "self-efficacy," "self-determination," "personal autonomy," "agency," "women's status," "women's rights," "malnutrition," "underweight," "overweight," "diet," "micronutrient," "vitamin," "nutrition education," "school feeding," "food supplementation," "women," "girls," "female," "maternal," "adolescent," "teenager," "youth."

Databases

An experienced medical information specialist developed and tested the search strategy using an iterative process in consultation with the review authors. A senior information specialist peer reviewed the search strategy prior to execution using the PRESS Checklist. We used a combination of controlled vocabulary (e.g., "Power [Psychology]," "Women's Rights," "Nutritional Status") and key words (e.g., empower, female status, and diet) for the concepts in all searches. We applied the Cochrane filter for low- and middle-income countries. Vocabulary and syntax were adjusted as necessary across the databases. We removed animal-only and opinion pieces from the results whenever possible. Using the OVID platform, we searched Ovid MEDLINE®, including Epub Ahead of Print and In-Process & Other Non-Indexed Citations, Embase Classic + Embase, PsycINFO, and the following EBM Reviews databases: Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Health Technology Assessment, and the NHS Economic Evaluation Database. We also searched CINAHL (Ebsco platform), Web of Science, and Popline. When the search was updated, Popline was no longer active and omitted.

We documented the search process in enough detail to ensure that it could be reported correctly in the review/update, including reporting the month and year the search began and ended.

Grey literature and handsearching

To identify potentially relevant unpublished materials, we contacted the following research groups and organisations, and/or consult their respective websites:

World Health Organisation Library (includes LILACS)

- Epistemonikos (no longer active when the search was updated)
- 3ie Impact and Systematic Review repositories
- E-Library of Evidence for Nutrition Actions (eLENA)
- UNICEF
- World Food Programme
- UNFPA
- International Food Policy Research Institute (IFPRI)
- Global Alliance for Improved Nutrition (GAIN)
- Nutrition International
- SPRING Project / USAID Advancing Nutrition
- International Centre for Research on Women (ICRW)
- UN Women
- Gender and Adolescence: Global Evidence (GAGE) Programme
- U.K. Department of International Development (DfID)
- Bill and Melinda Gates Foundation
- Plan International
- CARE
- Save the Children
- World Vision
- Young Lives
- Emergency Nutrition Network

Citation and reference lists

The citation and reference lists of included references, including other reviews, were searched. “Related articles” features of searched databases were used, where applicable. We conducted forward citation tracking using Scopus.

Contacting authors

We contacted authors of included studies to ask for suggested additional studies.

Screening of studies

Study selection was conducted in duplicate by two independent reviewers using the Covidence platform (www.covidence.org). Titles and abstracts resulting from the search strategy were independently screened by two reviewers in the first phase, followed by independent full-text review of eligible studies, also in duplicate. Any discrepancies between the independent reviewers were resolved by consensus, and in cases of disagreement, a third author was consulted. A PRISMA study selection flow chart [58] was prepared, and a list of excluded studies was compiled detailing the reason for each study's exclusion.

To minimise the risk of excluding eligible studies, we screened for nutrition-related activities only at the title and abstract phase. At the full-text screening stage, we further screened for the agency and opportunity structure components to determine study eligibility. In instances where articles did not provide a sufficient description of the intervention to determine its eligibility, we looked for companion articles describing the intervention, such as a published protocol or contacted the authors for additional information. Where we could not obtain additional information on the intervention, the studies were excluded from the review.

Description of methods used in primary research

The following study is an example of the expected eligible primary research methods:

Hewett et al. (2017) was a multi-arm cluster-RCT across 10 sites in four provinces of Zambia with randomisation to four different study arms (Intervention Arm 1, Intervention Arm 2, Intervention Arm 3, Control). The sites were evenly split between urban and rural settings (five sites each). The intervention assessed the effectiveness of the Adolescent Girls Empowerment Programme (AGEP), which consisted of weekly mentor-led girls' group meetings of 20 to 30 adolescent girls, participating over 2 years using curricula on sexual and reproductive health and life skills, financial literacy, and nutrition. Two additional components were a health voucher and bank account. Clusters were defined by national Census Supervisory Areas (CSAs) that were randomly selected to the experimental and control arms through a public lottery. Allocation concealment was unclear. Baseline behavioural surveys and biological specimen collection were conducted at the beginning of the trial, reassessed immediately after the programme ended (2015), and evaluated again at the 2-year follow-up point (2017). It is unclear if a cluster adjustment method was applied [59].

Criteria for determination of independent findings

Where studies reported different outcomes, these were pooled in separate meta-analyses. Whether there were several publications reporting on the same study, we used effect sizes from the most recent publication. Where studies included multiple outcome measures to assess related outcome constructs, we selected the outcome that reflected the outcome construct of interest most accurately. For studies in which multiple effects over time were reported, we used the effect sizes for the longest follow-up time.

Details of study coding strategies

Data extraction and quality assessment of included studies were completed in duplicate by two independent reviewers.

Quality assessment

We used the Campbell IDCG risk of bias tool to assess the quality of quantitative study designs (Hombrados & Waddington, 2012). The tool assessed risk of bias in the following categories:

- Selection bias and confounding
- Group equivalence
- Spillovers/crossovers/contamination
- Outcome reporting
- Analysis reporting
- Other risks of bias, including unit of analysis errors, detection bias and placebo effects, motivation and courtesy biases, coherence of results, and others.

Judgements made on risk of bias in quantitative studies were supported by specific information extracted from the study being assessed. An overall level of evidence quality (high, moderate, low, and very low) for each quantitative outcome was assigned as part of the GRADE process [60].

We appraised the quality of the qualitative studies using the Critical Appraisal Skills Programme (CASP) checklist for qualitative research [61]. We did not apply the GRADE CERQual approach was used to assess the overall confidence in the qualitative evidence synthesis because only one study was included in the qualitative synthesis [62].

Data extraction

Data extraction was conducted in duplicate by two independent reviewers. Reviewers used a pre-piloted data extraction form created in Google Sheets. Discrepancies between extractors were resolved through

discussion or by consultation with a third reviewer. The final data extraction forms are provided in Appendix B.

We extracted the following information for quantitative studies:

- Study objective
- Study population, including PROGRESS+ characteristics
- Study setting
- Study duration
- Key characteristics of study design, including recruitment and sampling procedures
- Key characteristics of study intervention
- Comparator description
- Study outcomes, measurement instruments, and timepoints
- Statistical procedures
- Description of the theoretical framework used to inform study design
- Details on the study context (geographic, economic, epidemiological, socio-cultural, legal, political, ethical)
- Study sample size (individuals and clusters, where appropriate)
- Participant baseline characteristics, including baseline differences between groups
- Intervention administrator and provider
- Implementation factors (reach, dose, fidelity, adaptation, co-intervention, contamination, engagement, quality, cultural adaptation)
- Study main findings, strengths, limitations
- Study ethical approval
- Study funding source

For quantitative outcomes, we extracted the following:

- For dichotomous outcomes, we extracted the total number of participants in the treatment and control groups and the total number experiencing the event in each group to allow the calculation of odds ratios and relative risks (or data necessary for their calculation).
- For normally distributed, continuous outcomes, we extracted means, standard deviations (or data necessary for their estimation) and the number of participants in each treatment group.

Outcomes that were measured at different time points were recorded separately. Quantitative data were entered into RevMan Web and checked for accuracy.

For qualitative studies, we extracted the views, experiences, and opinions of intervention participants, implementers and administrators on factors influencing the success or failure of interventions. Emphasis was placed on ascertaining the feasibility, appropriateness, and meaningfulness of the empowerment components of the intervention.

We extracted the following information for qualitative studies:

- Study objective
- Study population, including PROGRESS+ characteristics
- Study setting
- Study duration
- Key characteristics of study design, including recruitment and sampling procedures
- Analysis approach
- Phenomenon of interest
- Participant/provider/administrator perspectives on implementation and contextual factors
- Main findings
- Study strengths and limitations
- Study funding source
- Study ethical approval

Statistical procedures and conventions

Quantitative data was synthesised using meta-analysis, where appropriate. We expected a high level of heterogeneity since studies may employ a variety of different nutrition, agency, and opportunity structure activities. Consequently, we used a random effects model to produce an overall summary estimate, where an average treatment effect across studies was considered meaningful. Where meta-analysis was not possible or deemed inappropriate, results were reported using narrative synthesis, giving effect sizes and confidence intervals, where applicable.

We assessed heterogeneity among studies by first examining the heterogeneity at face-value in terms of the studies' populations, interventions, and outcomes. Second, we used tau-squared to statistically test for heterogeneity between studies. The accuracy of numeric data was checked by comparing the magnitude and direction of effects reported by studies and how they were presented in the review. A statistically nonsignificant p-value was interpreted as a finding of uncertainty unless confidence intervals were sufficiently narrow to rule out an important magnitude of effect.

Our base-case comparison was all studies (regardless of nutrition, agency, or opportunity structure component type) versus comparator. We were unable to conduct sensitivity analyses by intervention components, as planned, due to the low number of studies included in the review.

We analyzed experimental and quasi-experimental designs separately. We used change scores to assess the effects of outcomes from quasi-experimental studies. Where possible, we used correlation coefficient values identified in the literature to calculate change score SDs, and when not found, we used a conservative correlation coefficient value of 0.50 [63,64]. We use endline values to assess the effects of outcomes from randomized controlled trials.

Primary and secondary outcome data were extracted and analyzed separately. Binary outcomes were analyzed using risk ratios (±95% confidence interval (CI)). Continuous outcomes were analyzed using mean differences (±95% CI) and standardised mean differences when different units were used to measure the same outcome. In the random effects meta-analysis, Mantel-Haenszel (M-H) methods were used for binary outcomes, and the Inverse-Variance (I-V) method was used for continuous outcomes.

Unit of analysis errors were investigated to ensure estimates were properly adjusted for clustering. One included RCT (Bagherniya 2017) did not account for clustering in their analysis, and we used an intra-cluster correlation value of 0.05 to adjust the SDs. We conducted an intention-to-treat analysis. We documented how authors treated missing data. We did not conduct a sensitivity analysis to assess the effect of missing data since the degree of missingness and the number of included studies was small. Due to the low number of included studies, we were not able to conduct moderator analyses or assess publication bias.

Statistical support was provided by a statistician and meta-analyses were conducted using RevMan Web software. Results are displayed using forest plots.

The level of evidence was considered when formulating the review's conclusions. Where possible, differences in results were explained by giving a description of likely explanatory factors. A GRADE summary of findings table was prepared to summarize the strength of the review's evidence.

Treatment of qualitative research

We used the "best fit" framework synthesis method to synthesise data [65]. The "best fit" framework synthesis method allows for the testing or adaption of an existing model to a potentially different population. For this review, we adapted existing models for nutrition and empowerment to develop a logic model (described earlier) for adolescent girls' empowerment and nutrition and tested its applicability through the systematic review process. We coded qualitative data against the concepts

described at each level of the conceptual framework (e.g., implementation factors, expected outputs, shorter term outcomes, longer term outcomes). Inductive, thematic analysis techniques was used to synthesise data that did not align to the existing themes in the logic model.

The conclusions drawn from the quantitative and qualitative syntheses were combined to inform the revision of the logic model, and the formulation of the review's final discussion and conclusions. The discussion section includes reflections on the review's policy and research implications.

Protocol deviations

We report the following protocol deviations:

1. We did not apply the GRADE CERQual approach was used to assess the overall confidence in the qualitative evidence synthesis because only one study was included in the qualitative synthesis.
2. We analyzed experimental and quasi-experimental separately.
3. Where studies use different metrics for the same outcome, e.g., anemia status (binary) vs haemoglobin (continuous), we did not convert to the same metric using Borenstein's conversion formulae [66] to synthesise; instead, we reported the outcomes separately.

Results: Intervention effects on nutrition

Description of studies

Results of the search

We identified 23,837 records through database searching. An additional 1,876 records were identified through website searching and backward and forward citation tracking. After title and abstract screening, 1,000 reports were retrieved for full text screening. After applying our pre-specified screening criteria, 893 database reports and 91 website searching/citation tracking reports were excluded. This resulted in the identification of 10 quantitative studies with a total of 19 reports that met our inclusion criteria (Table 2).

Table 2. List of primary studies and companion reports.

Primary study	Companion reports
Alaofè 2009a	Alaofè 2009b
Bagherniya 2017	Bagherniya 2018
Dunker 2018a	Dunker 2018b[a,b], Dunker 2020[b]
Leme 2018	Leme 2015, Leme 2016, Leme 2019, Leme 2020, Philippi 2015
Dehdari 2014	--
Dehdari 2016	--
Jeihooni 2019	--
Jeihooni 2021	--
Kapadia-Kundu 2014	--
Sabet Sarvestani 2009	--

[a] Qualitative study.

[b] Study that assessed implementation factors.

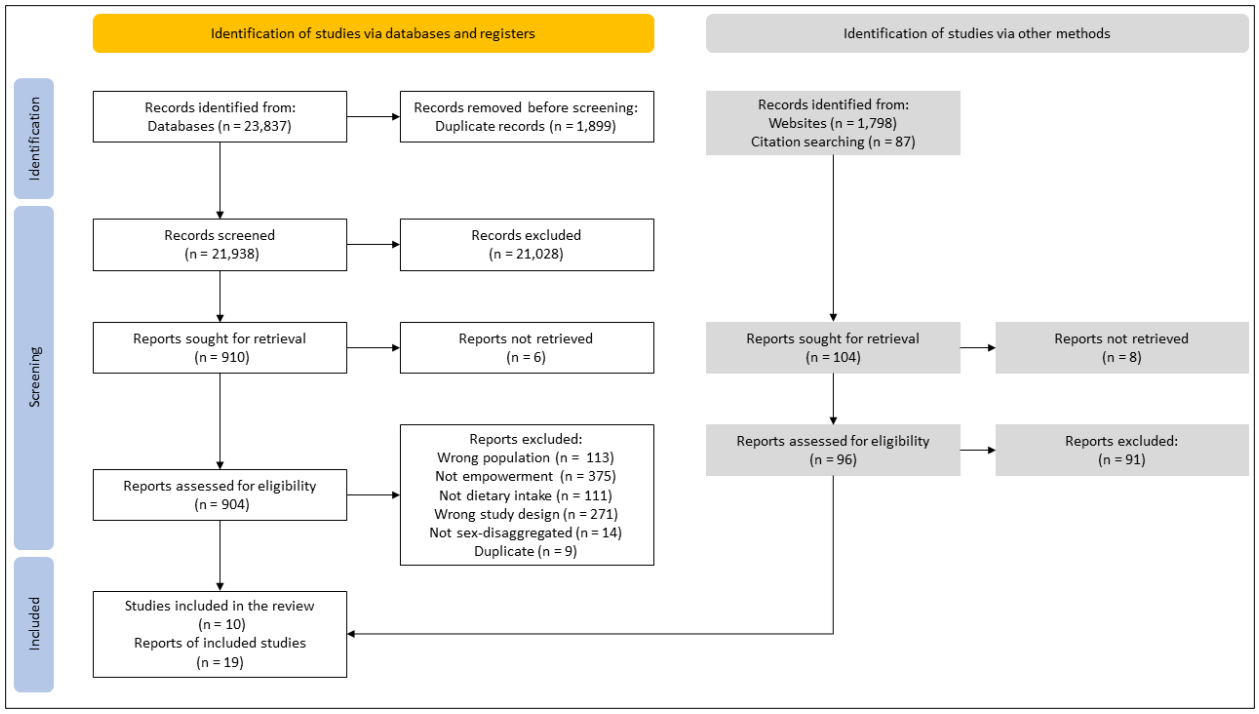


Figure 2. PRISMA flow chart.

Included studies

Study design

We included four experimental studies [67–70], of which all four were cluster RCTs. In addition, we included six quasi-experimental studies (nonrandomised controlled trials) [71–77], all of which used a controlled before-and-after (CBA) study design.

Study objectives

All studies aimed to improve participants' dietary habits or intake. Five studies sought to reduce participants' BMI (Leme 2018, Dunker 2018, Bagherniya 2017, Jeihooni 2019, Sabet Sarvestani 2009). Three studies addressed iron deficiency or anemia (Alaofè 2009, Jeihooni 2021, Kapadia-Kundu 2014). One study aimed to increase participants' breakfast intake (Dehdari 2014) and another study aimed to increase dairy intake (Dehdari 2016).

Study population

The age of study participants ranged from 11 years to 17 years. Three studies targeted adolescent girls who were overweight or obese (Bagherniya 2017, Jeihooni 2019, Sabet Sarvestani 2009). One study only included adolescent girls with mild iron deficiency anemia (Alaofè 2009). No studies included pregnant adolescents.

Six of the included studies were conducted in Iran (Bagherniya 2017, Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009). One study (Alaofè 2009) was conducted in Benin, two studies (Dunker 2018, Leme 2018) were conducted in Brazil, and one study (Kapadia-Kundu 2014) was conducted in India.

Considering country income at the time the studies were conducted, eight studies (80%) were conducted in an upper-middle income country (Iran (n=6), Brazil (n = 2)), one study (10%) was conducted in a lower-middle income country (India), and one study (10%) was conducted in a low-income country (Benin).

Study setting

All included studies were conducted in a school setting. One study (Alaofè 2009) was conducted in boarding schools. One study (Leme 2018) was conducted in technical high schools. Three studies (Dehdari 2014, Dehdari 2016, Bagherniya 2017) were conducted in middle schools. Two studies were undertaken in public high schools (Jeihooni 2019, Jeihooni 2021). One study only described the setting as "public schools" (Dunker 2018a). One study reported including private schools (Bagherniya 2017). One study was conducted in government schools (Kapadia-Kundu 2014). One study did not describe the type of school in which the study was undertaken (Sabet Sarvestani 2009).

Two studies were undertaken in a rural setting (Kapadia-Kundu 2014, Alaofè 2009). One study did not describe the study's geographical setting (Sabet Sarvestani 2009). All remaining studies were conducted in an urban setting. One study stated it was conducted in low-income communities (Leme 2018).

Nutrition component

All studies included a **nutrition education** component. One study (Dunker 2018a) conducted nutrition education workshops or group sessions with adolescent girls during school hours, and one study (Bagherniya 2017) conducted a mixture of in-school and after-school sessions. The remaining studies did not specify whether the sessions were held during school hours. Five studies (Bagherniya 2017, Dehdari 2014, Dehdari 2016, Dunker 2018a, Jeihooni 2019) provided written nutrition educational materials to participants, such as a nutrition handbook, recipe book, or booklet on the importance of eating breakfast. One study (Bagherniya 2017) provided participants and their parents with cooking classes and visits to industrial food companies as part of the nutrition education component.

One study (Dunker 2018a) provided participants with a **free meal** (lunch) on intervention activity days.

Agency component

We assessed this criterion by looking for evidence that the intervention included activities designed to increase adolescent girls' motivations and abilities to make informed decisions about their health and nutrition by creating space for self-reflection and goal setting.

At the individual level, **diaries, goal logs, and activity tracking** were used in several studies. Sabet Sarvestani et al. (2009) provided participants with a notebook to track their food intake and physical activity, and then encouraged participants to share their weekly successes and challenges with others in the group. Leme and colleagues (2018) provided participants with dietary/physical activity diaries to encourage goal setting and self-monitoring behaviours. Kapadia-Kundu et al. (2014) implemented the *Saloni* diary for participants to track their activities and document aspirations and long-term goals. Participants in Dehdari (2014) were provided a form to track their progress on implementing recommended practical steps for regular breakfast consumption and then discussed their progress with the intervention provider.

Some studies also employed **individually tailored counselling or advice** to support participants to make informed choices about their diet. Dunker et al. (2018a) provided participants with two sessions of individual counselling using motivational interviewing techniques.[2] Bagherniya et al. (2017) provided participants with monthly individual nutritional counselling sessions that included parents. In these sessions, participants set healthy diet goals and discussed with the researcher the best ways to achieve them. In Dehdari et al. (2014), intervention providers gave feedback to participants based on their breakfast consumption tracking form. Aloafe et al. (2009) held individual interviews with participants at three time points to discuss their eating habits and agree on recommendations for improvement.

Most studies implemented some form of **group discussion or (peer) small group work** to encourage self-reflection, problem-solving, and goal setting. Bagherniya et al. (2017) held interactive seminars for participants employing constructs from social cognitive theory to increase motivation for behaviour change and self-efficacy. Jeihooni et al. (2019, 2021) used small group discussions among peers and WhatsApp groups to reinforce healthy choices among participants through social support. Dehdari et al. (2014, 2016) also used small group work, in addition to role playing, to motivate and engage participants. Dunker et al. (2018) held interactive group educational sessions facilitated by a nutritionist and psychologist. Alaofè et al. (2009) utilized small group discussions and quizzes. Kapadia-Kundu et al.

[2] "[Motivational interviewing] is a collaborative, goal-oriented style of communication with particular attention to the language of change. It is designed to strengthen personal motivation for and commitment to a specific goal by eliciting and exploring the person's own reasons for change within an atmosphere of acceptance and compassion." [110]

(2014) held group education sessions employing the health competence model, described as "having the knowledge, attitudes, skills and resources to act consistently and appropriately across multiple health behaviours." Leme et al. (2019) used social cognitive theory in nutrition workshops and interactive seminars to increase participants' self-efficacy, skills, and motivation for behaviour change. In the weekly nutrition education sessions given by Sabet Sarvestani et al. (2009), participants were taught problem solving skills and were encouraged to share they successes and challenges with the group.

Only one study (Kapadia-Kundu 2014) included a **skill building** focus. Participants were trained in intergenerational communication to empower them to share their nutrition learning and needs with parents and to address "asymmetrical communication between girls and family members/father" (p.170).

Opportunity structure component

Engaging parents was a common strategy for building a supportive opportunity structure. We classified the engagement strategies as either passive or active. Passive strategies for parental engagement included text messages (Bagherniya 2017, Jeihooni 2021) and newsletters/pamphlets (Bagherniya 2017, Dehdari 2014, Dunker 2018, Leme 2018). Active parental engagement strategies were phone calls (Bagherniya 2017) and educational seminars (Bagherniya 2017, Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009).

Five studies **engaged teachers** through seminars (Bagherniya 2017, Dehdari 2014, Dehdari 2016, Jeihooni 2019, Sabet Sarvestani 2009) and/or written materials (Dehdari 2014).

Two studies targeted **changes to the food environment**. One study (Aloafe 2009) assessed and made changes to boarding school menus to promote iron intake. Another study (Jeihooni 2019) worked with the education department to review school buffets and prohibit the sale of junk food in intervention schools.

One study (Kapadia-Kundu 2014) included a **community engagement** component to maintain commitment to a girl-centred health program, advocate for and mobilize the community around fulfilling the health and social needs of girls, and to change social norms.

Other intervention components

Four studies (Leme 2018, Jeihooni 2019, Dunker 2018, Sabet Sarvestani 2009) included a **physical activity** component as part of the intervention arm. One study (Leme 2018) provided enhanced weekly physical education classes and physical activity during recess. One study (Jeihooni 2019) provided physical activity education alongside a rope and slimming loop to encourage activity. One study (Sabet Sarvestani 2009) provided weekly yoga sessions to participants, and the final study (Dunker 2018) provided group physical activity sessions.

One study (Kapadia-Kundu 2014) provided weekly **iron and folic acid tablets** to both the intervention and control arms.

Two studies conducted **deworming** activities among participants in the intervention and control arms. Kapadia-Kundu et al. (2014) conducted six-monthly deworming treatments and Alaofè et al. (2009) treated all participants initially with anthelmintic and antimalaria drugs. The same anthelmintic drug was given monthly thereafter when new infections were detected over the course of the study.

Comparators

Comparator groups either received no intervention or usual care (Dehdari 2014, Dunker 2018, Kapadia-Kundu 2014). Five studies provided some form of the intervention to the comparator group at the study's conclusion (Bagherniya 2017, Alaofè 2009, Leme 2018, Jeihooni 2019, Jeihooni 2021).

Outcomes

Primary outcomes

Five studies (Sabet Sarvestani 2009, Jeihooni 2019, Leme 2018, Bagherniya 2017, Dunker 2018) assessed changes in BMI (kg/m^2). Three studies (Jeihooni 2019, Sabet Sarvestani 2009, Leme 2018) assessed changes in weight (kg). One study (Sabet Sarvestani 2009) assessed changes in arm circumference (cm). Two studies (Leme 2018, Bagherniya 2017) assessed changes in waist circumference (cm).

Two studies (Alaofè 2009, Jeihooni 2021) assessed changes in haemoglobin (g/L) and serum ferritin (µg/L). One study (Alaofè 2009) assessed changes in total iron binding capacity (TIBC) (µmol/L), transferrin saturation (%) and serum iron (µmol/L). One study (Jeihooni 2019) assessed changes in mean hematocrit (%).

Secondary outcomes

Five studies assessed mean changes in total energy intake (kcal) using different methods. Bagherniya (2017) used a self-administered 24-hr recall from midnight to midnight. Alaofè et al. (2009) conducted dietary assessments using a 48-hr recall tool. Leme et al. (2018) used the Brazilian Food Frequency Questionnaire [78]. Dehdari et al. (2014) used a 3-day breakfast record to measure total dietary intake, and Dehdari et al. (2016) used a 3-day record of dairy foods consumed. Table 3 summarizes the dietary intake measures used by study.

Table 3. Dietary intake measures by study.

Outcome	Alaofe 2009	Dehdari 2014	Dehdari 2016	Bagherniya 2017	Leme 2018
Total energy intake (kcal/day)	X	X	X	X	X
Carbohydrates (g/day)	X	X	X		
Dietary fibre (g/day)		X	X		
Fat (g/day)	X		X		
Saturated fatty acid			X		
Monosaturated fatty acids			X		
Polyunsaturated fatty acids			X		
Protein (g/day)	X	X	X		
Cholesterol (mg/day)		X	X		
Calcium (mg/day)	X	X	X		
Zinc (mg/day)	X	X	X		
Vitamin A (µg/day)	X	X	X		
Vitamin B6 (mg/day)		X	X		
Vitamin B12 (µg/day)	X	X	X		
Vitamin D (mg/day)			X		
Folate (µg/day)	X				
Folic acid (µg/day)		X	X		
Vitamin E (mg/day)		X	X		
Thiamin (mg/day)		X	X		
Riboflavin (mg/day)		X	X		
Pantothenic acid (µg/day)		X	X		
Selenium (µg/day)		X	X		
Niacin (mg/day)		X	X		
Dietary iron (mg/day)	X	X	X		
Nonheme iron (mg/day)	X				
Heme iron (mg/day)	X				
Absorbable iron (mg/day)	X				
Magnesium (mg/day)		X	X		
Potassium (mg/day)		X	X		
Copper (mg/day)		X	X		
Phosphorus (mg/day)		X	X		
Vitamin C (mg/day)	X	X	X		
Daily servings of F&V				X	
Daily servings of fruits					X
Daily servings of vegetables					X
Daily servings of low-fat dairy				X	

Outcome	Alaofe 2009	Dehdari 2014	Dehdari 2016	Bagherniya 2017	Leme 2018
Daily servings of dairy			X		
Daily servings of Milk					X
Daily servings of fats and oils				X	
Daily servings of oils					X
Daily servings of rice					X
Daily servings of meat					X
Daily servings of beans					X
Daily servings of sweets					X
Worthless junk foods (g/day)				X	

One study (Kapadia-Kundu 2014) assessed the following health behaviours: consumption of ≥ 24 weekly iron and folic acid (WIFA) tablets in the last 6 months, weekly consumption of IFA for girls using directly observed treatment (DOT), food variety consumed using an index cut-off (>8), consumption of at least three meals and one snack daily, consumption of vitamin C rich foods in the week prior to the survey (Y/N), consumption of sprouted legumes in the week prior to the survey (Y/N), consumption of deworming tablet every 6 months (Y/N), annual health check-up (Y/N). One study (Dehdari 2014) assessed the weekly frequency of breakfast consumption.

Duration

Study duration ranged from at least four months to 22 months.

Table 4. Characteristics of included studies.

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
Bagherniya 2017 **Duration**: 7.5 months	Cluster RCT	To improve dietary habits and reduce BMI	**Participants**: Overweight or obese adolescent girls (12-16 yrs) **Setting**: School, Shahinshahr, Iran	**Nutrition component**: 14 x 1hr bi-weekly nutrition education sessions, visits to industrial food companies, healthy cooking workshops **Agency component**: Social Cognitive Theory, private counselling, motivational test messages, motivational calls **Opportunity structure component**: Nutrition workshops for parents and teachers (one per month); parents accompany visits to food companies, cooking workshops and counselling sessions; text messages to parents; calls to parents **Comparator**: No intervention. Nutrition lectures and educational materials provided to control group following study conclusion	**Anthropometry** BMI (kg/m2) Waist circumference (cm) **Dietary intake** Total energy intake (kcal/day) Fruits and vegetables (servings/day) Low fat dairy (servings/day) Fats and oils (servings/day) Worthless junk foods (g/day) **Social cognitive** Dietary self-efficacy Dietary social support Dietary outcome expectations Dietary outcome expectancies Dietary intention Dietary situation
Alaofè 2009	Controlled Before-After Study	To reduce iron deficiency anemia (IDA)	**Participants**: Adolescent girls with mild IDA (12-17 yrs)	**Nutrition component**: 4 x weekly nutrition education sessions	**Iron status** Serum ferritin (µg/L) Serum iron (µmol/L)

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
Duration: 5.5 months			**Setting**: Boarding school, South Benin	**Agency component**: Individual advice/counselling; peer small group work; group discussion; use of problem solving and motivation techniques **Opportunity structure component**: School cafeteria menu changes to increase bioavailability of dietary iron **Other intervention components:** anthelmintic and anti-malarial treatment **Comparator**: Anthelmintic and anti-malarial treatment; nutrition education at study conclusion	TIBC (µmol/L) Transferrin saturation (%) Haemoglobin (g/L) **Dietary intake** Dietary iron (mg/day) Nonheme iron (mg/day) Heme iron (mg/day) Absorbable iron (mg/day) VItamin C (mg/day) Total energy (kcal/day) Carbohydrate (g/day) Fat (g/day) Protein (g/day) Calcium (mg/day) Zinc (mg/day) Vitamin A (RAE/day) Vitamin B12 (µg/day) Folate (µg/day)
Kapadia-Kundu 2014 **Duration**: 22 months	Cluster RCT	To improve health behaviors associated with anemia, maternal mortality, and undernutrition	**Participants**: Adolescent girls (11-14 yrs) **Setting**: School, rural Uttar Pradesh, India	**"Saloni Pilot Program"** **Nutrition component**: 10 x 1hr monthly nutrition education sessions **Agency component**: Health Competence (social ecology) model; Saloni diary (track long term goals and aspirations);	**Nutrition behaviours** At least 3 meals + snack Food variety index > 8 Consumption of sprouted legumes Consumption of vitamin C foods

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
				intergenerational communication skills building **Opportunity structure component**: Community engagement and sensitization to support girl-focused health programming **Other intervention components:** Education on health seeking, reproductive health, and hygiene; weekly IFA supplementation, anthelmintic treatment 2x/yr **Comparator**: Education on health seeking, reproductive health, and hygiene; weekly IFA supplementation, anthelmintic treatment 2x/yr	Weekly IFA consumption Weekly IFA consumption using DOTS Annual health check-up **Health service utilization** Consumed >= 24 weekly iron & folic (IFA) tablets in last 6 months
Leme 2018 **Duration**: 12 months	Cluster RCT	To reduce BMI, unhealthy weight control behaviours, and weight stigma	**Participants**: Adolescent girls attending 1st-3rd year high school **Setting**: Technical high school, low-income communities in Sao Paolo, Brazil	**"H3G-Brazil"** **Nutrition component**: 3 x 90min nutrition workshops; 3 x 1hr interactive seminars; 10 x 20min weekly nutrition messages, nutrition handbook **Agency component**: Social Cognitive Theory, nutrition goalsetting diaries; interactive seminars; peer text message groups **Opportunity structure component:** Parent newsletters **Other intervention components:** Physical	**Anthropometry** BMI (kg/m2) BMI z-score Weight (kg) Waist circumference (cm) **Dietary intake** Estimated energy intake (kcal/day) Rice group (servings/day) Veggies group (servings/day) Fruits group

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
				education classes and physical activity sessions; promotion of body acceptance and discouragement of unhealthy weight control practices and weight-related teasing **Comparator**: No intervention. Control group received a condensed version of the intervention at study conclusion.	(servings/day) Milk group (servings/day) Meats group (servings/day) Beans group (servings/day) Oils group (servings/day) Sweets group (servings/day) **Social cognitive** Healthy eating self-efficacy Healthy eating intentions Healthy eating social support Healthy eating strategies Healthy eating environment Healthy eating outcome expectations Healthy eating outcome expectancies
Dehdari 2014 **Duration**: 3 months	Controlled Before-After Study	To improve the frequency and nutrient intake of breakfast consumption	**Participants**: Adolescent girls attending middle school	**Nutrition component**: 4 x 1hr weekly nutrition education sessions **Agency component**: Pender's Health	**Healthy behaviours** Weekly frequency of breakfast consumption

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
			Setting: Middle school, Qom, Iran	Promotion Model; self-efficacy focused education session; discussion groups; peer small group work, individually tailored advice **Opportunity structure component**: 1 x training session for teachers; pamphlet for teachers; 1 x training session for mothers; pamphlet for mothers **Comparator**: Usual classroom nutrition education (provided to intervention group also)	**Dietary intake** Total energy (kJ/breakfast daily) Total protein (g/breakfast daily) Carbohydrate (g/breakfast daily) Dietary fibre (g/breakfast daily) Cholesterol (mg/breakfast daily) Vitamin A (µg/breakfast daily) Thiamin (mg/breakfast daily) Riboflavin (mg/breakfast daily) Niacin (mg/breakfast daily) Vitamin B6 (mg/breakfast daily) Vitamin B12 (mg/breakfast daily) Folic acid (µg/breakfast daily) Pantothenic acid (µg/breakfast daily) Vitamin C (mg/breakfast daily) Vitamin E

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
					(mg/breakfast daily) Ca (mg/breakfast daily) Cu (mg/breakfast daily) Fe (mg/breakfast daily) Mg (mg/breakfast daily) P (mg/breakfast daily) K (mg/breakfast daily) Se (µg/breakfast daily) Zn (mg/breakfast daily) **HPM constructs** Prior related behaviour Perceived benefits of breakfast eating Perceived barriers to eating breakfast Perceived self-efficacy Positive affect Negative affect Interpersonal influences Situational influences Immediate competing demands and

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
					preferences Commitment to planning for breakfast
Jeihooni 2019 **Duration**: Unclear - at least 4 months	Controlled Before-After Study	To improve dietary habits and physical activity, and reduce BMI	Participants: Obese adolescent girls attending high school Setting: High school, Fasa City, Iran	**Nutrition component**: 10 x hr nutrition education sessions, educational booklet **Agency component**: PRECEDE model, group discussions, peer support through Whatsapp **Opportunity structure component**: Changes to school buffet, junk food sales prohibited; 1 x education session for parents and school officials **Other intervention components:** Physical activity education and provision of rope and slimming loop to encourage exercise **Comparator**: No intervention. 1 x educational session and an educational booklet provided at the end of the study	**Anthropometry** BMI (kg/m2) Weight (kg) **PRECEDE constructs** Knowledge Attitude Self-efficacy Enabling factors Reinforcing factors Nutrition performance
Dunker 2018 **Duration**: 6.5 months	Cluster RCT	To improve dietary habits and physical activity, and reduce BMI	**Participants**: Adolescent girls (12-14 yrs) practicing less than one daily hour of physical activity **Setting**: Public school, Sao Paolo, Brazil	**"New Moves Program"** **Nutrition component**: 8 x 1hr weekly nutrition education sessions, didactic materials (e.g., recipe book, posters), lunch provision on NMP days, 8 x weekly group lunch meetings **Agency component**: Social Cognitive Theory, interactive group sessions with dietitians and	**Anthropometry** BMI (kg/m2) **Social cognitive** Rosenberg self-esteem scale

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
				psychologists, 2 x individual counselling sessions using motivational interviewing techniques **Opportunity structure component**: NMP postcards for parents; teacher training **Other intervention components:** Group physical activity sessions **Comparator**: Classes instructed "as usual"	
Jeihooni 2021 **Duration:** Unclear - at least 5 months	Controlled Before-After Study	To reduce iron deficiency anemia (IDA)	**Participants**: Adolescent girls in 7th and 8th grade **Setting**: Public high school, Fasa City, Iran	**Nutrition component:** 6 x nutrition education sessions; educational booklet **Agency component:** PRECEDE model; peer group work; peer Whatsapp peer group **Opportunity structure component:** teacher, school official and family sessions (one per week) **Comparator:** No intervention. Education session provided at end of study	**Nutrition** Hemoglobin (g/L) Hematocrit (%) Ferritin (μg/L) **PRECEDE constructs** Knowledge Attitude Self-efficacy Reinforcing factors Enabling factors Preventive behaviours
Dehdari 2016 **Duration:** 8 months	Controlled Before-After Study	To increase dairy consumption	**Participants:** Adolescent girls in 7th grade **Setting:** Middle school, Aborz, Iran	**Nutrition component:** 4 x 45-50min nutrition training sessions **Agency component:** Pender's Health Promotion Model; self-efficacy focused education session; large group discussion; peer small group work	**Dietary intake** Number of servings of dairy foods consumed per day Total energy intake (kJ) Carbohydrates (g) Dietary fibre (g)

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
				Opportunity structure component: 1 x training session for parents and teachers **Comparator:** Not described.	Fat (g) Saturated fatty acids (g) Monosaturated fatty acids (g) Polysaturated fatty acids (g) Protein (g) Cholesterol (mg) Calcium (mg) Zinc (mg) Vitamin A (ug) Vitamin B6 (mg) Vitamin B12 (ug) Vitamin D (mg) Folic acid (ug) Vitamin E (mg) Thiamin (mg) Riboflavin (mg) Pantothenic acid (mg) Selenium (ug) Niacin (mg) Dietary iron (mg) Magnesium (mg) Potassium (mg) Copper (mg) Phosphorus (mg) Vitamin C (mg) Servings of dairy / day **HPM constructs**

Study ID and duration	Study Design	Aim	Participants and setting	Intervention	Outcomes
					Perceived benefits Perceived barriers Self-efficacy beliefs Positive feelings Negative feelings Interpersonal influences Situational influences Competing demands and preferences Commitment to a plan of action
Sabet-Sarvestani 2009 **Duration**: 4 months	Controlled Before-After Study	To improve eating behaviours and reduce BMI	**Participants**: Obese adolescent girls aged 11-15 years **Setting**: Iran	**Nutrition component**: 16 x 2hr weekly nutrition education sessions; 4 x dietitican appointments **Agency component**: Cognitive restructuring; problem solving skills; large group discussion; peer small group work **Opportunity structure component**: 1 x session with parents **Other intervention component:** 16 x 2hr weekly yoga sessions **Comparator**: Unclear. "Attended 3 sessions of same program"	**Anthropometric** Weight (kg) BMI (kg/m2) Arm circumference (cm) **Eating behaviours** Emotional eating External eating Restrained eating

Excluded studies

Studies were excluded for the following reasons: wrong study design (n = 313), wrong population (n = 125), lacking a complete empowerment model (n = 394), primary purpose is not to improve dietary intake (n = 116), data not sex-disaggregated (n = 14), wrong outcomes (n = 4).

Of note are the 13 studies that met our inclusion criteria but did not sex-disaggregate their results [79–92]. In other words, the studies' populations included adolescent boys and girls but did not conduct sub-group analyses by sex. We contacted study authors to request sex-disaggregated data but did not receive the data required to include the studies in our analysis.

Risk of bias in included studies

We used the Campbell IDCG risk of bias tool to assess all quantitative study designs [93]. A rating of "yes" meant the study had a low risk of bias for the assessed criterion. The results are summarized in Table 5. Two studies were rated at low risk of bias. Two studies were rated at moderate risk of bias, and six studies were rated at high risk of bias. Detailed justifications for the ratings are provided in Appendix C.

Selection bias and confounding

Three RCTs (Leme 2018, Dunker 2018a, Kapadia-Kundu 2014) were rated as having a low risk of selection bias. One RCT (Bagherniya 2017) was rated as having an unclear risk of selection bias. Five out of six NRS (Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009) were rated as having a high risk of selection bias and confounding. One NRS was rated as having an unclear risk of bias for selection bias and confounding.

Group equivalence

All RCTs (Leme 2018, Bagherniya 2017, Dunker 2018, Kapadia-Kundu 2014) and one NRS (Alaofè 2009a) were rated as having an unclear risk of bias for group equivalence. The remaining NRS (Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009) were rated as having a high risk of bias for group equivalence.

Hawthorne and John Henry effects

All RCTs and NRS were rated as having an unclear risk of bias due to participant reactivity to being observed (Hawthorne effect) or being in the control group (John Henry Effect).

Spillover and contamination

Two RCTs (Dunker 2018a, Kapadia-Kundu 2014) were rated at low risk of bias due to spillover or contamination. The remaining RCTs (Bagherniya 2017, Leme 2018) and NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sarvestani 2009) were rated as having an unclear risk of bias due to spillover or contamination.

Outcome reporting

One RCT (Kapadia-Kundu 2014) was rated as having an unclear risk of bias for selective outcome reporting. All other included studies were rated as having a low risk of bias.

Analysis reporting

Four RCTs (Bagherniya 2017, Dunker 2018a, Leme 2018, Kapadia-Kundu 2014) and one NRS (Alaofè 2009a) were rating as having a low risk of bias for analysis reporting. The remaining NRS were rated as having a high risk of bias (Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009).

Other risks of bias

Three RCTs (Bagherniya 2017, Dunker 2018a, Leme 2018) were rated as having a low risk of other forms of bias. One RCT (Kapadia-Kundu 2014) and four NRS (Alaofè 2009a, Jeihooni 2019, Jeihooni 2021, Sabet Sarvestani 2009) were rated as having an unclear risk of the bias. Two NRS (Dehdari 2014, Dehdari 2016) were rated as having a high risk of bias.

Confidence intervals

One RCT (Kapadia-Kundu 2014) and three NRS (Alaofè 2009a, Jeihooni 2021, and Sabet Sarvestani 2009) was rated as having a low risk of bias. One RCT (Dunker 2018a) and one NRS (Jeihooni 2019) were rated as having an unclear risk of bias. Two RCT (Bagherniya 2017, and Leme 2018) and two NRS (Dehdari 2014, Dehdari 2016) were rated as having a high risk of bias.

Table 5. Risk of bias assessments for included quantitative studies.

Study	Selection bias and confounding	Group equivalence	Hawthorne and John Henry effects	Spillover and contamination	Outcome reporting	Analysis reporting	Other risks of bias	Confidence intervals	Overall risk of bias
Randomized studies									
Bagherniya 2017	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	No	High
Dunker 2018	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Unclear	Low
Kapadia-Kundu 2014	Yes	Unclear	Unclear	Yes	Unclear	Yes	Unclear	Yes	Moderate
Leme 2018	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	No	Low
Non-randomized studies									
Alaofè 2009	Unclear	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes	Moderate
Dehdari 2014	No	No	Unclear	Unclear	Yes	No	No	No	High
Dehdari 2016	No	No	Unclear	Unclear	Yes	No	No	No	High
Jeihooni 2019	No	No	Unclear	Unclear	Yes	No	Unclear	Unclear	High
Jeihooni 2021	No	No	Unclear	Unclear	Yes	No	Unclear	Yes	High
Sarvestani 2009	No	No	Unclear	Unclear	Yes	No	Unclear	Yes	High

Effects of interventions

The results summarized here are for the comparison of a complete empowerment model versus usual care/no comparator.

Primary outcomes

BMI

RCTs

Three RCTs (Leme 2018, Dunker 2018a, Bagherniya 2017) conducted in middle-income countries with 608 adolescent girls assessed this outcome. One of the included RCTs (Bagherniya 2017) included overweight or obese participants only. There was some heterogeneity ($Tau^2 = 0.12$; $Chi^2 = 2.67$, df = 2; $I^2 = 25\%$). Our analysis showed a non-significant effect on BMI (MD: -0.01, 95% CI: -0.77, 0.76; moderate certainty).

NRS

Two NRS (Jeihooni 2019, Sabet Sarvestani 2009) conducted in Iran with 260 overweight or obese adolescent girls were included the meta-analysis. There was no heterogeneity ($Tau^2 = 0.00$; $Chi^2 = 0.15$, df = 1 (P = 0.70); $I^2 = 0\%$). Our analysis found a significant effect on BMI (MD: -1.14, 95% CI: -1.62, -0.66; very low certainty).

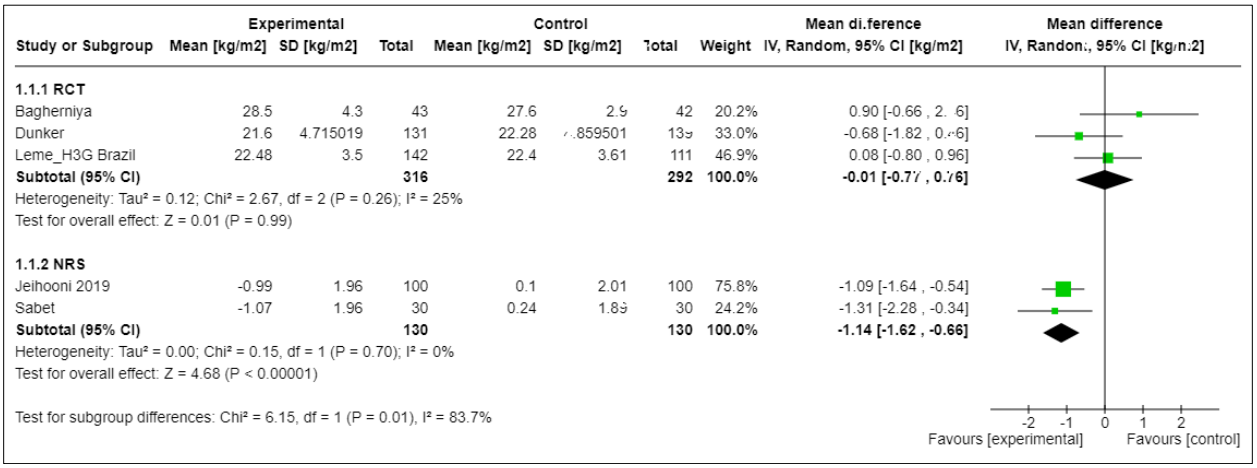


Figure 1. Analysis 1 | Comparison: Complete empowerment model v. Control | Outcome: BMI (kg/m2).

Waist circumference

RCTs

Two RCTs (Bagherniya 2017, Leme 2018) conducted in middle-income countries with 338 adolescent girls assessed this outcome. Our analysis found a non-significant effect on waist circumference (MD: -0.02, 95% CI: -2.44, 2.40; low certainty). Some heterogeneity was present ($Tau^2 = 0.93$; $Chi^2 = 1.40$, df = 1 (P = 0.24); $I^2 = 28\%$). One of the included RCTs (Bagherniya 2017) include overweight or obese participants only.

NRS

No NRS assessed waist circumference.

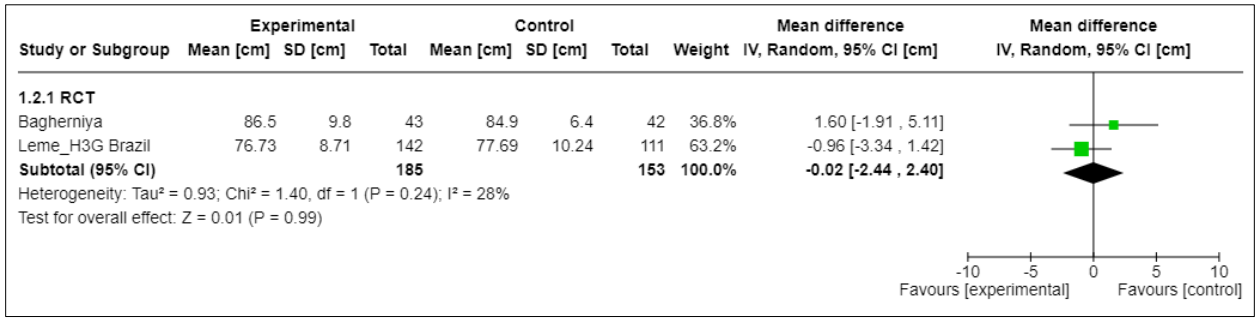


Figure 2. Analysis 2 | Comparison: Complete empowerment model v. Control | Outcome: Waist circumference (cm).

Arm circumference

RCTs

No RCTs assessed arm circumference.

NRS

One NRS (Sabet Sarvestani 2009) conducted in Iran with 60 obese adolescent girls assessed this outcome. Our analysis found a significant effect on arm circumference (MD: -2.81, 95% CI: -3.70, -1.92; very low certainty).

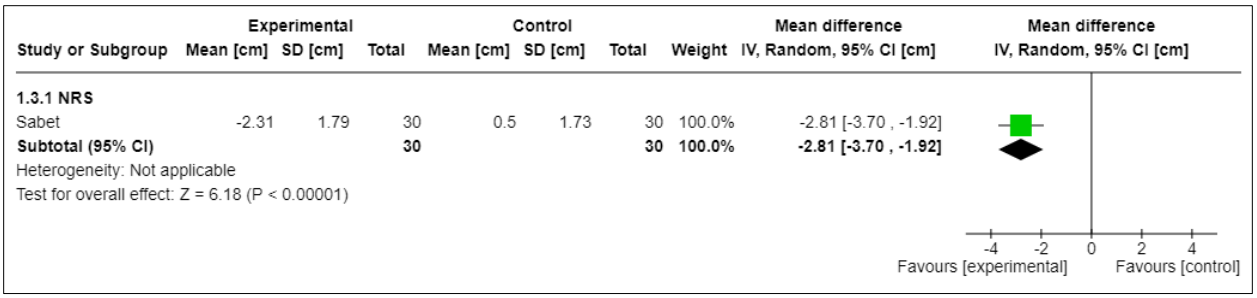


Figure 3. Analysis 3 | Comparison: Complete empowerment model v. Control | Outcome: Arm circumference (cm).

Haemoglobin

RCT

No RCTs assessed haemoglobin.

NRS

Two NRS (Alaofè 2009a, Jeihooni 2021) conducted in Benin and Iran with 228 adolescent girls assessed this outcome. Due to high heterogeneity ($Tau^2 = 0.17$; $Chi^2 = 9.23$, df = 1 (P = 0.002); $I^2 = 89\%$), we did not meta-analyse the data. Our analysis of Alaofè 2009a (study population: 68 adolescent girls with mild iron deficiency anemia) found a significant effect on Hb (MD: 0.95, 95% CI: 0.65, 1.25; very low certainty). Our analysis of Jeihooni et al. (2021) (study population: 142 adolescent girls) also found a significant effect on Hb (MD: 0.34, 95% CI: 0.08, 0.60; very low certainty).

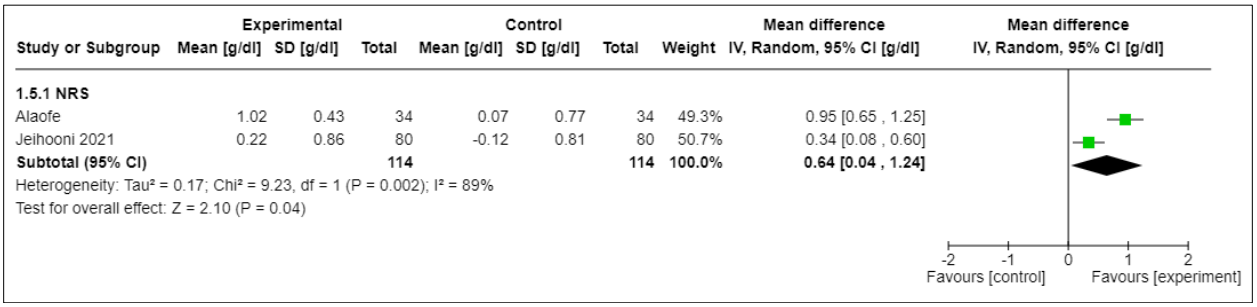


Figure 4. Analysis 4 | Comparison: Complete empowerment model v. Control | Outcome: Haemoglobin (g/dL).

Anemia

RCT

No RCTs assessed anemia.

NRS

One NRS (Alaofè 2009a) (study population: 68 adolescent girls with IDA) reported this outcome. Our analysis found a relative risk of anemia of 0.38 (95% CI: 0.23, 0.63; very low certainty) among girls in the intervention arm.

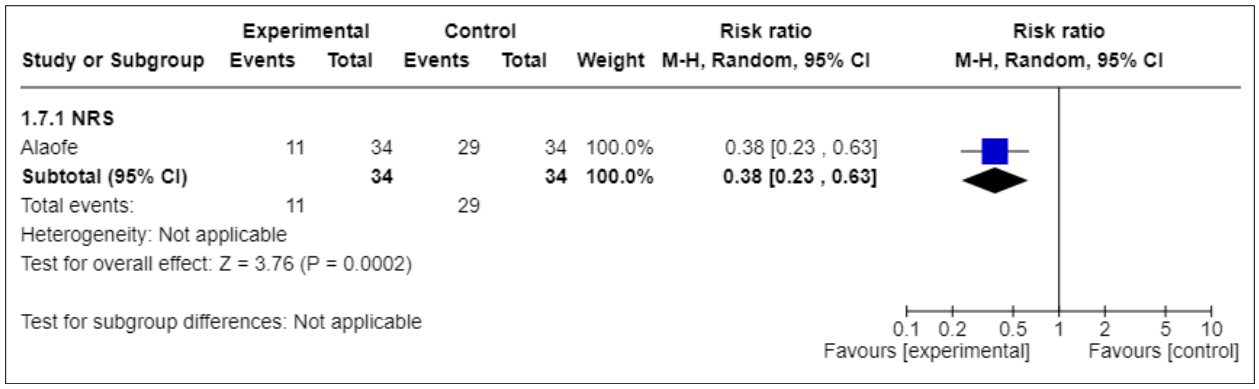


Figure 5. Analysis 5 | Comparison: Complete empowerment model v. Control | Outcome: Anemia (RR).

Serum ferritin

RCT

No RCTs assessed serum ferritin.

NRS

Two NRS (Alaofè 2009a, Jeihooni 2021) among 228 adolescent girls in Benin and Iran, respectively, assessed serum ferritin. There was no heterogeneity ($Tau^2 = 0.00$; $Chi^2 = 0.22$, df = 1 (P = 0.64); $I^2 = 0\%$). Our analysis found a significant effect on serum ferritin (MD: 8.24, 95% CI: 3.31, 13.18; very low certainty).

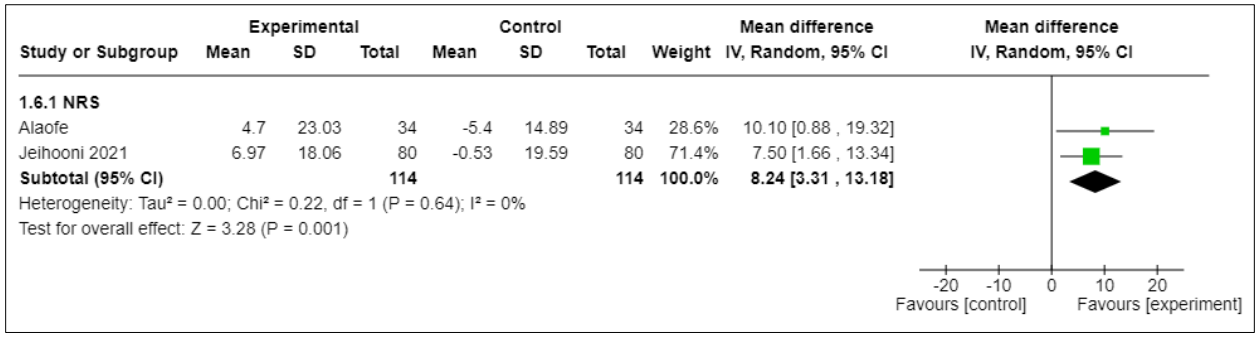


Figure 6. Analysis 6 | Comparison: Complete empowerment model v. Control | Outcome: Serum ferritin (µg/L).

Secondary outcomes

Total dietary intake

RCT

Two RCTs (Bagherniya 2017, Leme 2018) with 318 adolescent girls that aimed at BMI reduction measured total energy intake assessed this outcome. There was moderate heterogeneity ($Tau^2 = 0.04$; $Chi^2 = 2.31$, df = 1 (P = 0.13); $I^2 = 57\%$). Our analysis found a non-significant effect on total energy intake in (SMD: -0.15, 95% CI: -0.52, 0.22; low certainty).

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls that aimed to increase dietary intake of specific foods assessed this outcome. There was substantial heterogeneity ($Tau^2 = 0.30$; $Chi^2 = 16.29$, df = 2 (P = 0.0003); $I^2 = 88\%$) and the results were not meta-analysed. Our analysis of Alaofè 2009a found a significant effect on total dietary intake (SMD: 0.74, 95% CI: 0.25, 1.23; very low certainty). Similarly, our analysis of Dehdari 2014 also found a significant effect on total dietary intake (SMD: 0.48, 95% CI: 0.08, 0.88). In contrast, our analysis of Dehdari 2016 found a small but significant negative effect on total dietary intake (SMD: -0.33, 95% CI: -0.66, -0.00; very low certainty).

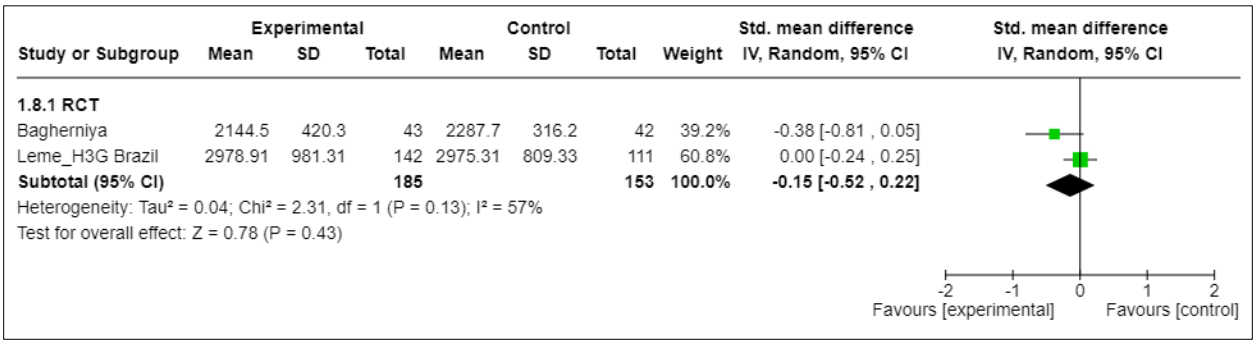


Figure 7. Analysis 7.1 | Comparison: Complete empowerment model v. Control | Outcome: Total dietary intake (decrease).

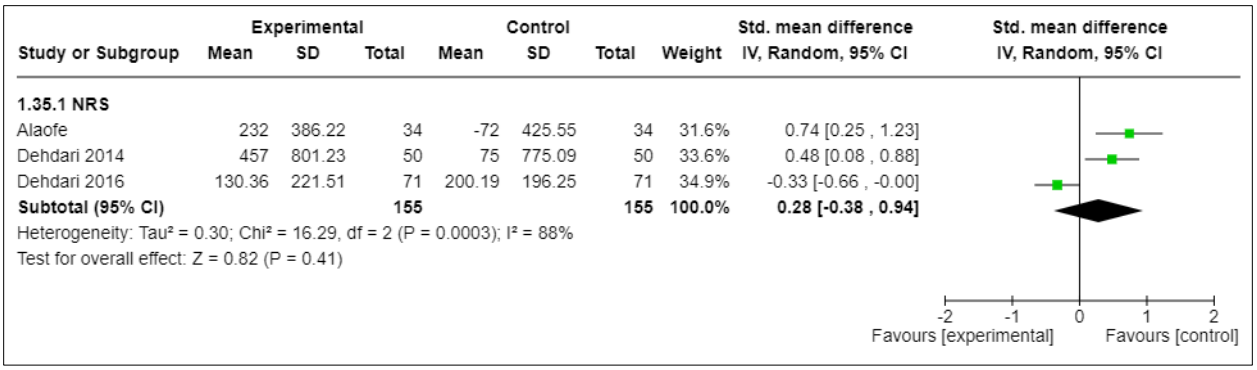


Figure 8. Analysis 7.2 | Comparison: Complete empowerment model v. Control | Outcome: Total dietary intake (increase).

Total protein

RCTs

No RCTs assessed total protein intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls evaluated total protein intake. The results were highly heterogenous (Tau² = 0.15; Chi² = 9.28, df = 2 (P = 0.010); I² = 78%) and were not meta-analysed. Our analysis of Alaofè 2009a found a significant effect on total protein intake (SMD: 0.68, 95% CI: 0.19, 1.17; very low certainty). Our analysis of Dehdari et al. 2014 found a non-significant effect (SMD: 0.32, 95% CI: -0.07, 0.72; very low certainty). Likewise, our analysis of Dehdari 2016 found a non-significant effect (SMD: -0.19, 95%CI: -0.52, 0.14; very low certainty).

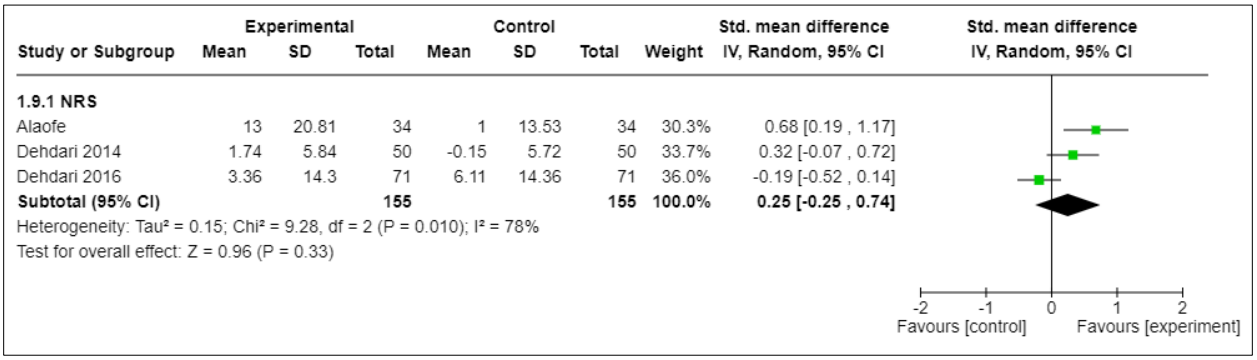


Figure 9. Analysis 8 | Comparison: Complete empowerment model v. Control | Outcome: Protein intake (SD).

Calcium

RCTs

No RCTs assessed calcium intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls assessed this outcome. There was moderate heterogeneity ($Tau^2 = 0.05$; $Chi^2 = 4.25$, df = 2 (P = 0.12); $I^2 = 53\%$). Our analysis found a significant effect on calcium intake (SMD: 0.37, 95% CI: 0.03, 0.71; very low certainty).

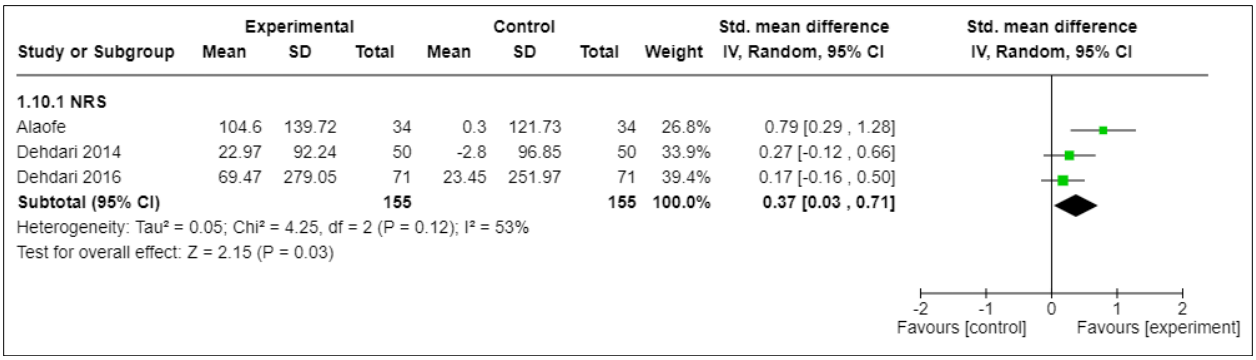


Figure 10. Analysis 9 | Comparison: Complete empowerment model v. Control | Outcome: Calcium intake (SD).

Dietary iron

RCTs

No RCTs assessed dietary iron intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls assessed dietary iron intake. There was moderate heterogeneity ($Tau^2 = 0.11$; $Chi^2 = 7.34$, df = 2 (P = 0.03); $I^2 = 73\%$). Our analysis found a non-significant effect on dietary iron intake (SMD: 0.33 (95% CI: -0.12, 0.77; very low certainty).

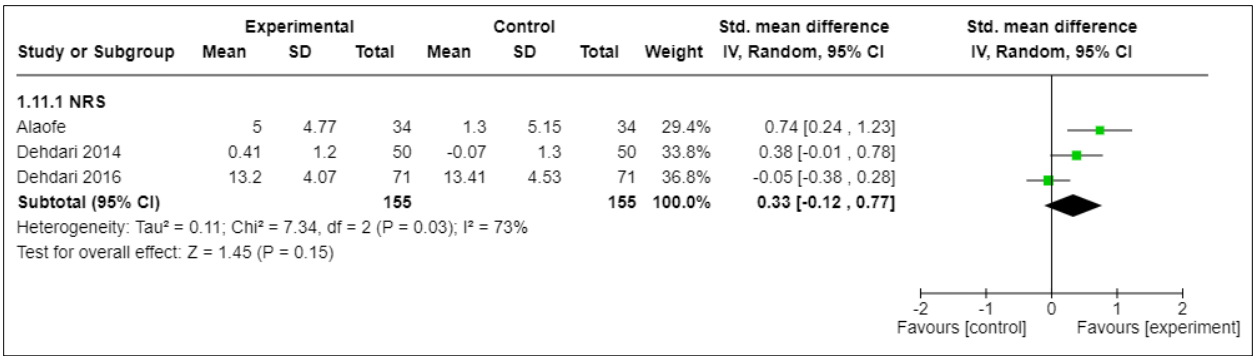


Figure 11. Analysis 10 | Comparison: Complete empowerment model v. Control | Outcome: Dietary iron intake (SD).

Folate

RCTs

No RCTs assessed folate intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls assessed folate intake. There was high heterogeneity (Tau² = 0.25; Chi² = 13.44, df = 2 (P = 0.001); I² = 85%). Our analysis of Alaofè 2009a found a significant effect on folate intake (SMD: 1.13, 95% CI: 0.61, 1.64; very low certainty). Our analysis of Dehdari 2014 found a smaller but still significant effect on folate intake (SMD: 0.59, 95% CI: 0.19, 0.99; very low certainty). Our analysis of Dehdari 2016 found a non-significant effect on folate intake (SMD: 0.55, 95% CI: -0.06, 1.17; very low certainty).

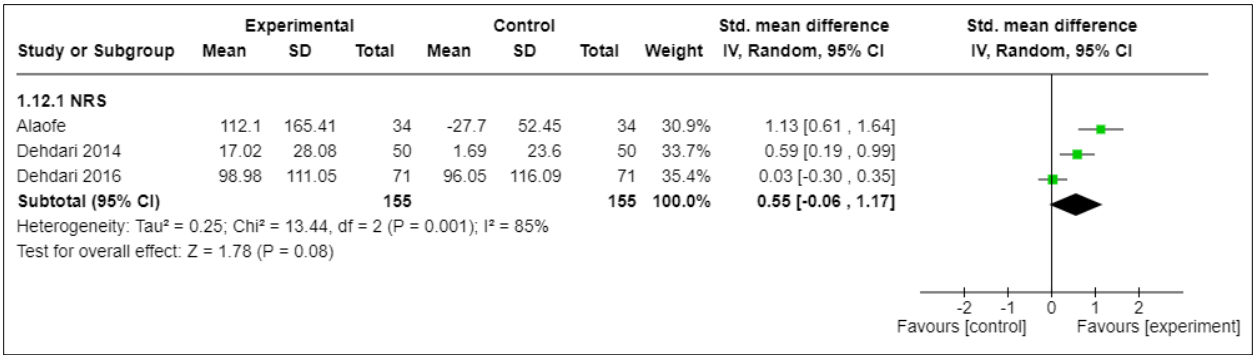


Figure 12. Analysis 11 | Comparison: Complete empowerment model v. Control | Outcome: Folate intake (SD).

Vitamin A

RCTs

No RCTs assessed vitamin A intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls assessed vitamin A intake. There was moderate heterogeneity ($Tau^2 = 0.06$; $Chi^2 = 4.94$, df = 2 (P = 0.08); $I^2 = 60\%$). Our analysis found a non-significant effect on vitamin A intake (SMD: 0.32, -0.05, 0.68; very low certainty).

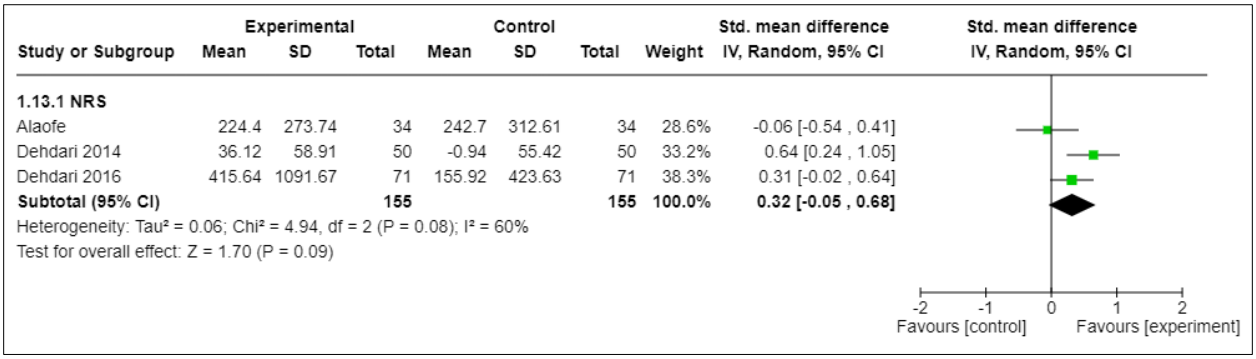


Figure 13. Analysis 12 | Comparison: Complete empowerment model v. Control | Outcome: Vitamin A intake (SD).

Zinc

RCTs

No RCTs assessed zinc intake.

NRS

Three NRS (Alaofè 2009a, Dehdari 2014, Dehdari 2016) with 310 adolescent girls assessed zinc intake. There was high heterogeneity ($Tau^2 = 0.35$; $Chi^2 = 18.23$, df = 2 (P = 0.0001); $I^2 = 89\%$) and the results were not meta-analysed. Our analysis of Alaofè 2009 found a significant effect on zinc intake (SMD: 1.23, 95% CI: 0.71, 1.76; very low certainty). Our analysis of Dehdari 2014 also found a significant effect (SMD: 0.48, 95%CI: 0.08, 0.88; very low certainty). Our analysis of Dehdari 2016 found a non-significant effect (SMD: -0.09, 95% CI: -0.42, 0.24; very low certainty).

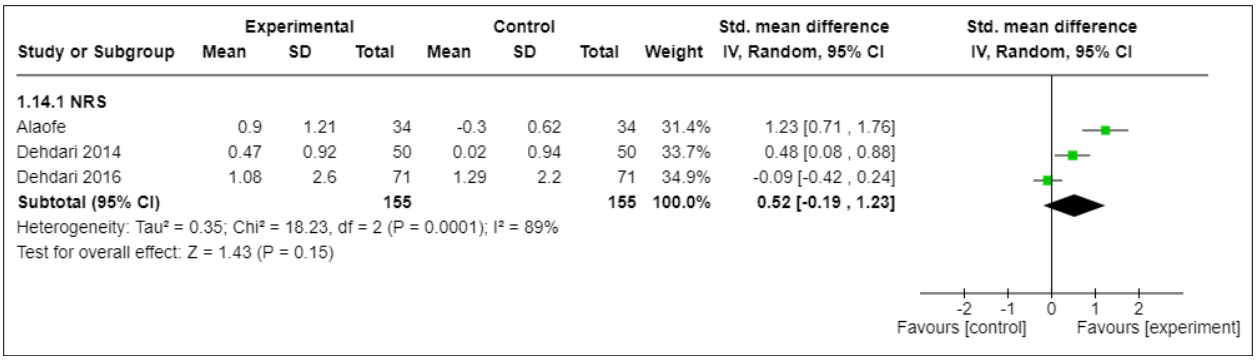


Figure 14. Analysis 13 | Comparison: Complete empowerment model v. Control | Outcome: Zinc (SD).

Fruit and vegetable servings

RCTs

Two RCTs (Bagherniya 2017, Leme 2018) assessed fruit and/or vegetable serving consumption. Our analysis of Bagherniya 2017 (study population: 172 overweight adolescent girls) found a significant positive effect on fruit and vegetable serving consumption (MD: 5.00, 95% CI: 3.81, 6.19; very low certainty). Our analysis of Leme 2018 (study population: 253 participants adolescent girls) found no effect on fruit serving consumption (MD: 0.01, 95% CI: -0.34, 0.36; low certainty) but a significant effect on vegetable serving consumption (MD: 1.17, 95% CI: 0.35, 1.99; low certainty).

NRS

No NRS assessed fruit or vegetable serving consumption.

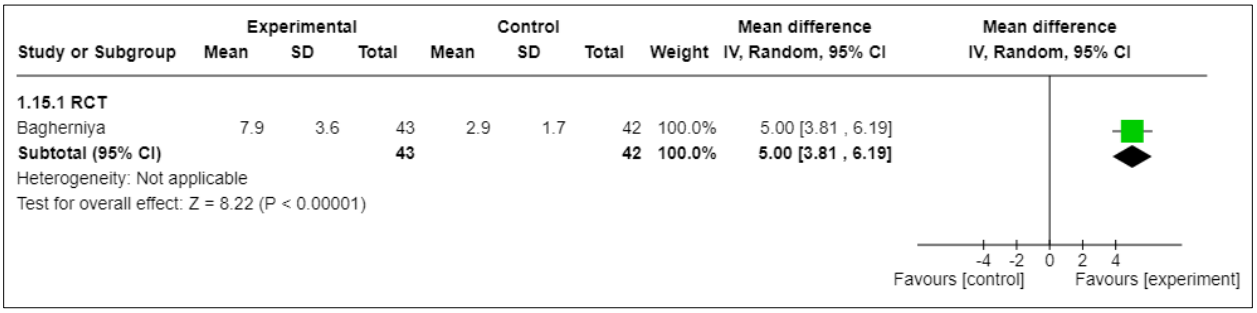


Figure 15. Analysis 14.1 | Comparison: Complete empowerment model v. Control | Outcome: Fruits and vegetables combined (daily servings).

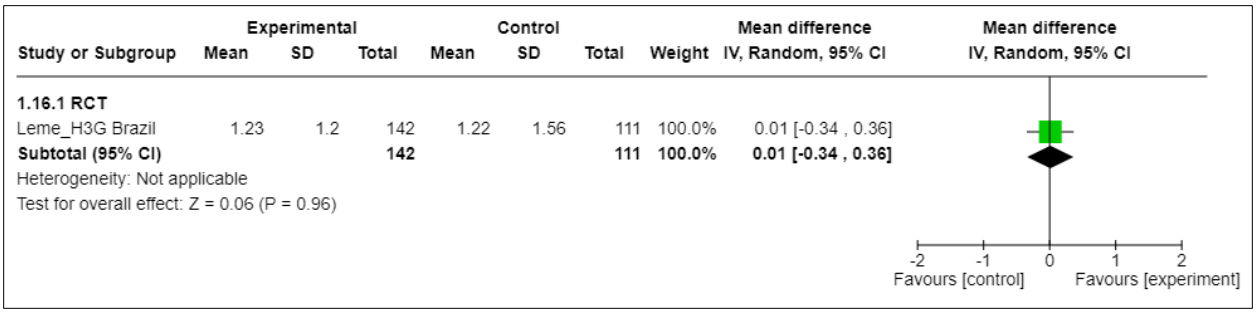


Figure 16. Analysis 14.2 | Comparison: Complete empowerment model v. Control | Outcome: Fruits (daily servings).

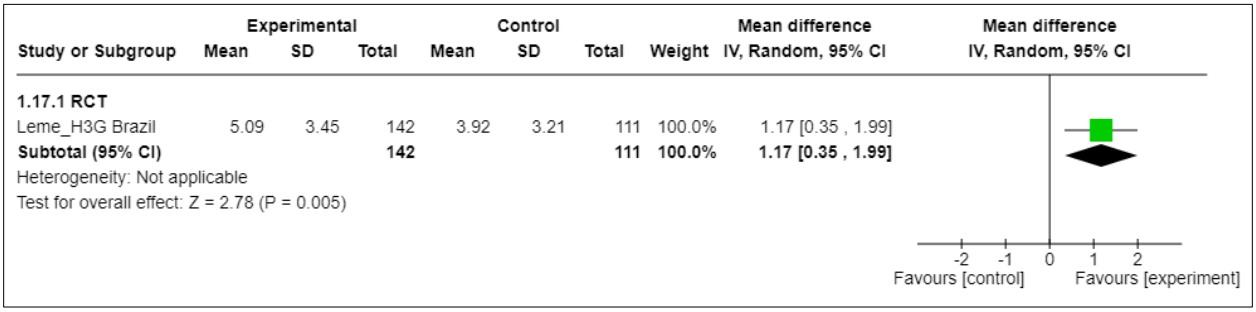


Figure 17. Analysis 14.3 | Comparison: Complete empowerment model v. Control | Outcome: Vegetables (daily servings).

Dairy servings

RCT

Two RCTs (Bagherniya 2017, Leme 2018) assessed dairy serving consumption. There was high heterogeneity ($Tau^2 = 1.93$; $Chi^2 = 45.70$, df = 1 ($P < 0.00001$); $I^2 = 98\%$) and the results were not meta-analysed. Our analysis of Bagherniya 2017 found a significant effect on dairy serving consumption (SMD: 1.93, 95% CI: 1.41, 2.45; very low certainty) while our analysis of Leme 2018 (study population: 253 participants adolescent girls) found a non-significant effect (SMD: -0.05, 95% CI: -0.30, 0.20; low certainty).

NRS

One NRS (Dehdari 2016) assessed dairy serving consumption among 142 adolescent girls. Our analysis of the data found a significant effect on dairy consumption (SMD: 0.46, 95% CI: 0.13, 0.79; very low certainty).

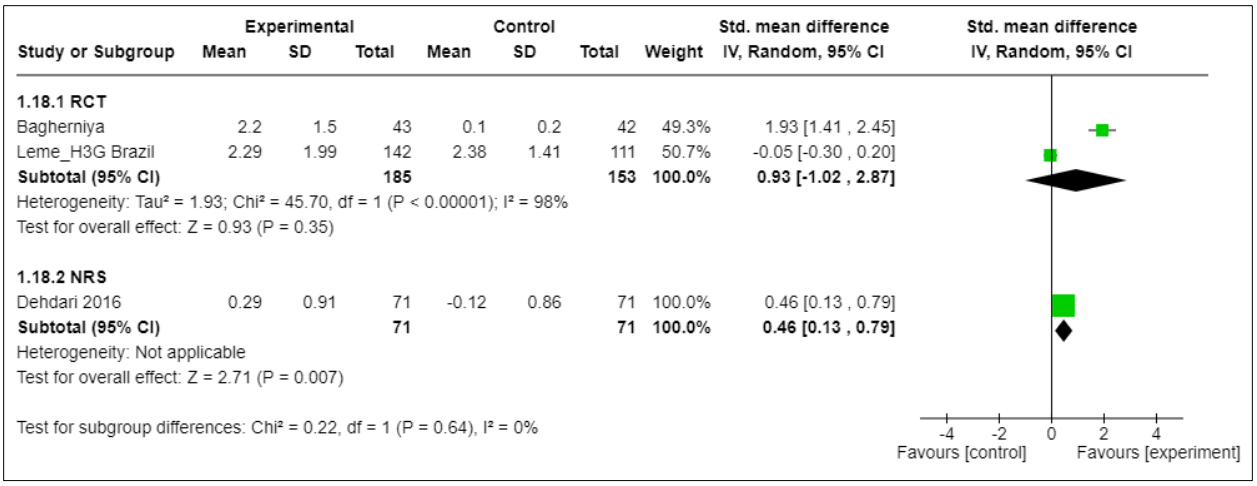


Figure 18. Analysis 15 | Comparison: Complete empowerment model v. Control | Outcome: Dairy servings (SD).

Fat and oil servings

RCT

Two RCTs (Bagherniya 2017, Leme 2018) assessed changes in fat or oil servings. There was high heterogeneity ($Tau^2 = 0.55$; $Chi^2 = 16.00$, df = 1 ($P < 0.0001$); $I^2 = 94\%$) and the results were not meta-analysed. Our analysis of Bagherniya 2017 (study population: 172 overweight adolescent girls) found a significant effect on fat and oil serving consumption (SMD: -1.27, 95% CI: -1.74, -0.80; very low certainty). Our analysis of Leme 2018 (study population: 253 participants adolescent girls) found a non-significant effect on oil serving consumption (SMD: -0.19, 95% CI: -0.44, 0.06; low certainty).

NRS

No NRS assessed fat or oil serving consumption.

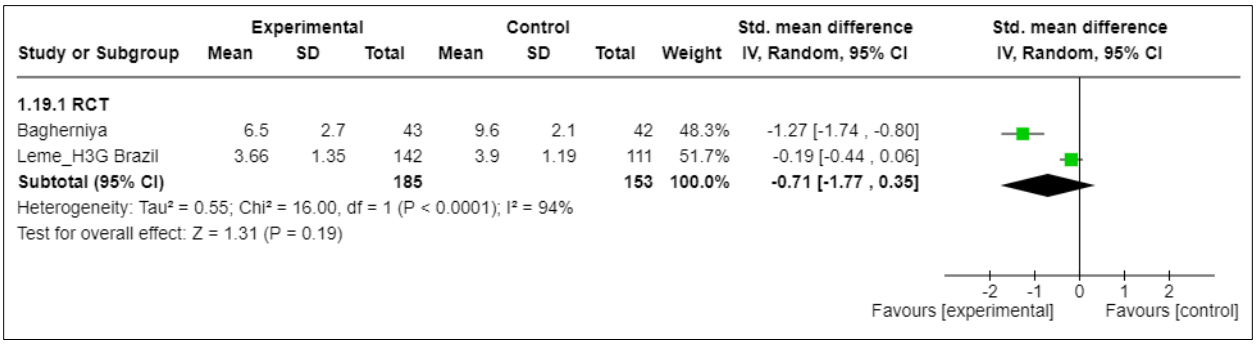


Figure 19. Analysis 16 | Comparison: Complete empowerment model v. Control | Outcome: Fat and oil servings (SD).

Sweets servings

RCT

One RCTs (Leme 2018) (study population: 253 participants adolescent girls) assessed this outcome. Our analysis found a significant effect on sweets serving consumption (MD: -0.81, 95% CI: -1.14, -0.48: low certainty).

NRS

No NRS assessed sweets serving consumption.

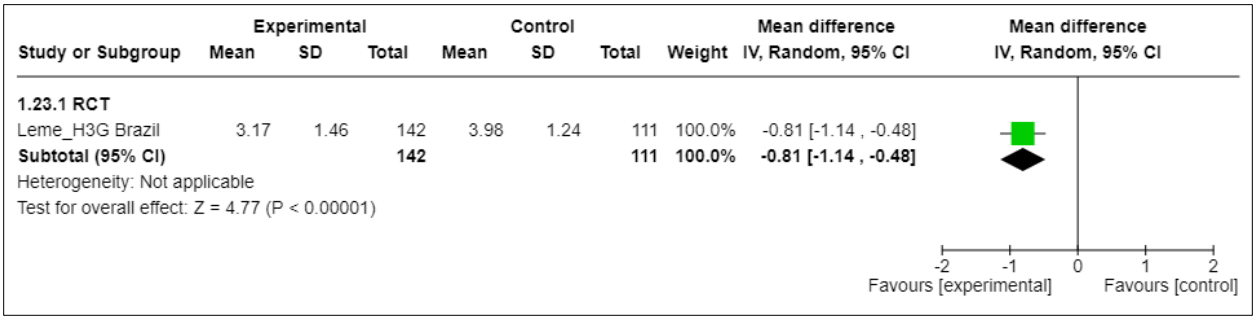


Figure 20. Analysis 17 | Comparison: Complete empowerment model v. Control | Outcome: Sweets (daily servings).

Junk food servings

RCT

One RCT (Bagherniya 2017) (study population: 172 overweight adolescent girls) assessed this outcome. Our analysis found a significant effect on junk food serving consumption (MD: -60.7, 95% CI: -84.88, -36.52; very low certainty).

NRS

No NRS assessed junk food serving consumption.

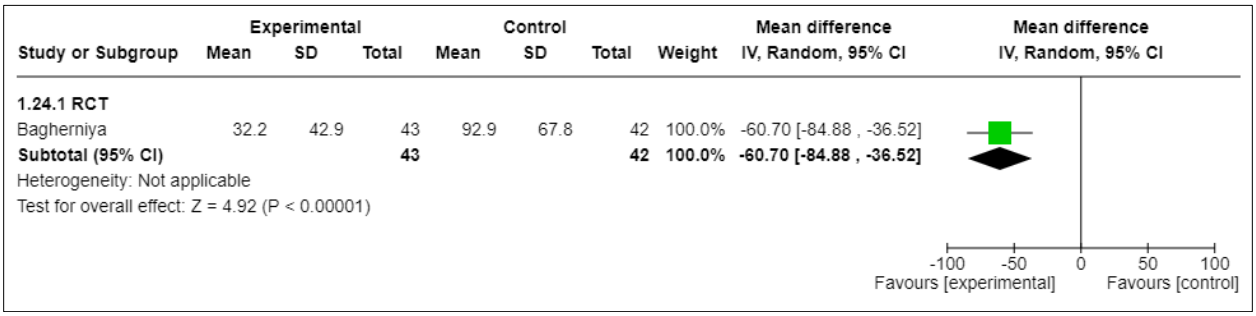


Figure 21. Analysis 18 | Comparison: Complete empowerment model v. Control | Outcome: Junk food (g).

Health behaviours

Daily consumption of three meals and a snack

RCT

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on daily consumption of three meals and a snack (RR: 1.31, 95% CI: 1.12, 1.43; moderate certainty).

NRS

No NRS assessed this health behaviour.

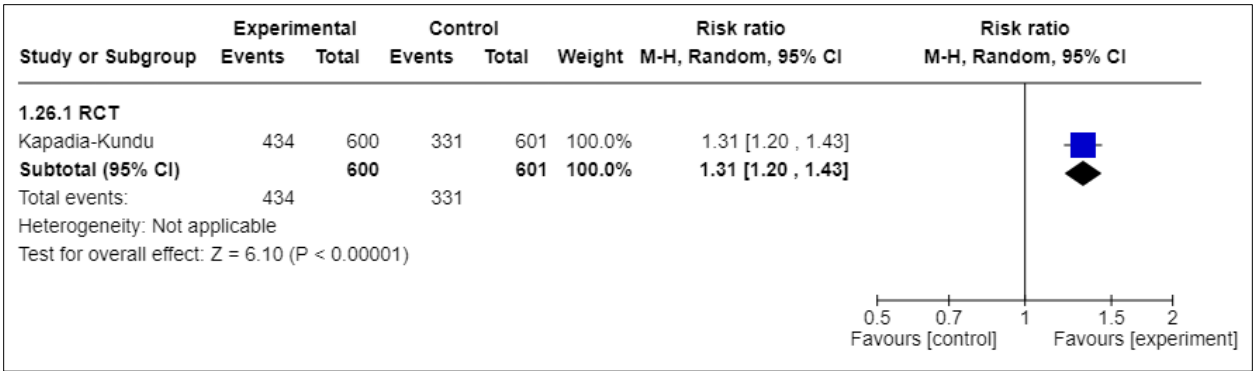


Figure 22. Analysis 19 | Comparison: Complete empowerment model v. Control | Outcome: Daily consumption of 3 meals + 1 snack (RR).

Food variety index > 8

RCT

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on food variety consumption (RR: 1.24, 95% CI: 1.13, 1.36; moderate certainty).

NRS

No NRS assessed this health behaviour.

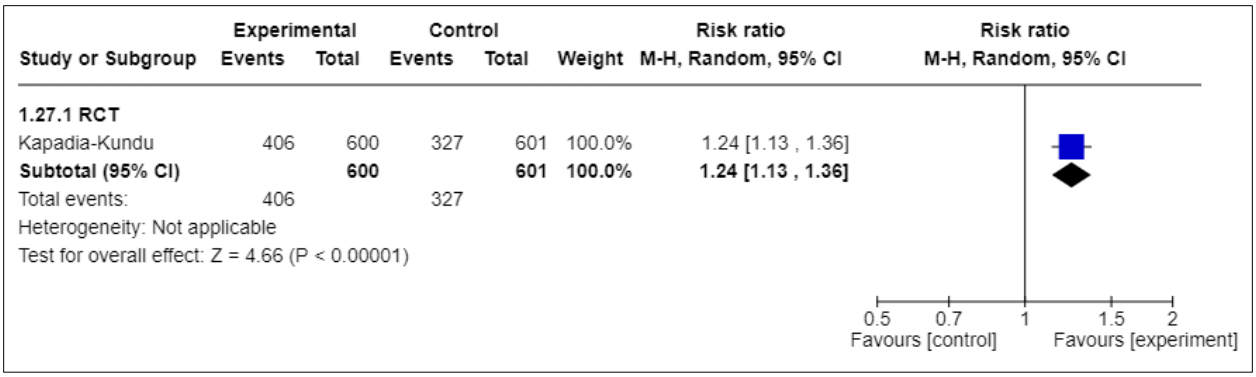


Figure 23. Analysis 20 | Comparison: Complete empowerment model v. Control | Outcome: Food variety index > 8 (RR).

Consumption of sprouted legumes

RCTs

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the consumption of sprouted legumes (RR: 3.22, 95% CI: 2.57, 4.03; moderate certainty).

NRS

No NRS assessed this health behaviour.

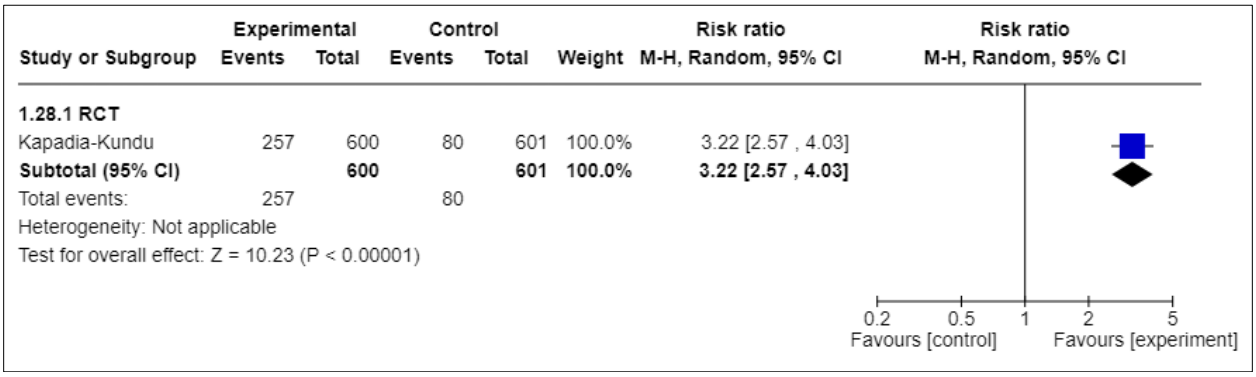


Figure 24. Analysis 21 | Comparison: Complete empowerment model v. Control | Outcome: Consumption of sprouted legumes (RR).

Consumption of vitamin C foods

RCT

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the consumption of vitamin C foods (RR: 1.85, 95% CI: 1.55, 2.20; moderate certainty).

NRS

No NRS assessed this health behaviour.

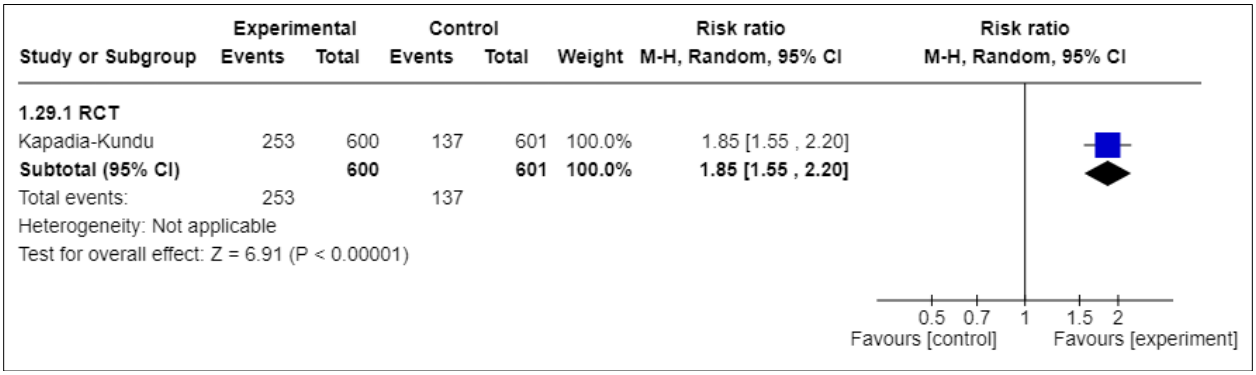


Figure 25. Analysis 22 | Comparison: Complete empowerment model v. Control | Outcome: Consumption of vitamin C foods (RR).

IFA consumption

RCT

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the consumption of more than 24 IFA tablets in the previous six months (RR: 6.38, 95% CI: 5.12, 7.94; moderate certainty).

NRS

No NRS assessed this health behaviour.

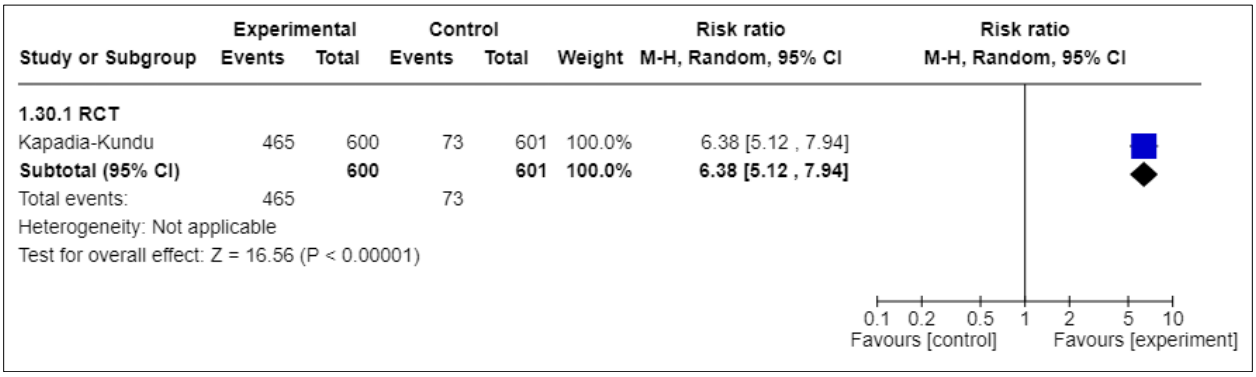


Figure 26. Analysis 23 | Comparison: Complete empowerment model v. Control | Outcome: Consumption of IFA tablets (RR).

DOTS for IFA consumption

RCT

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the use of DOTS among adolescent girls who consumed IFA tablets (RR: 3.67, 95% CI: 3.11, 4.33; moderate certainty).

NRS

No NRS assessed this health behaviour.

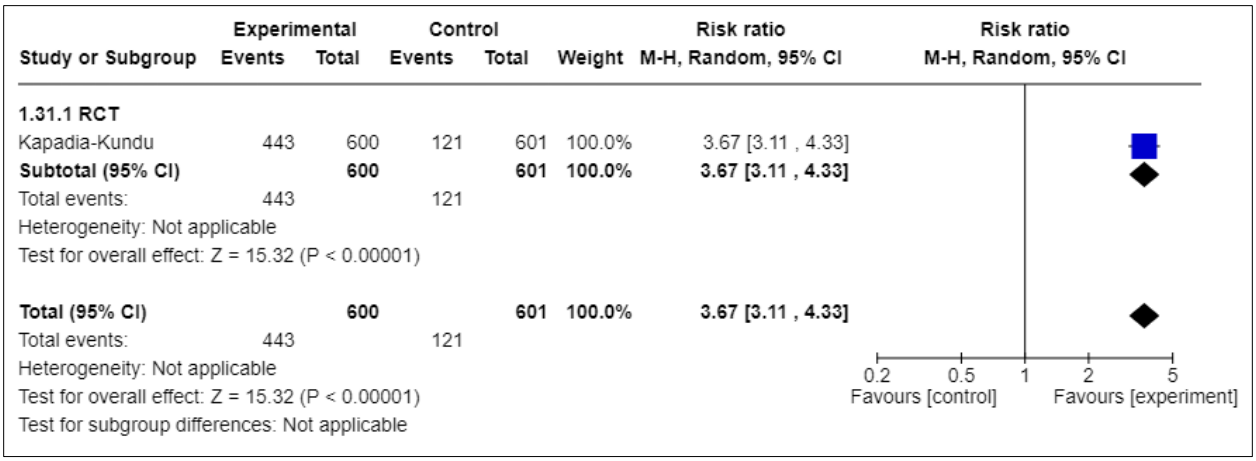


Figure 27. Analysis 24 | Comparison: Complete empowerment model v. Control | Outcome: DOTS for IFA (RR).

Annual health check-up

RCTs

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the take-up of an annual school health check up (RR: 6.54, 95% CI: 5.11, 8.38; moderate certainty).

NRS

No NRS assessed this health behaviour.

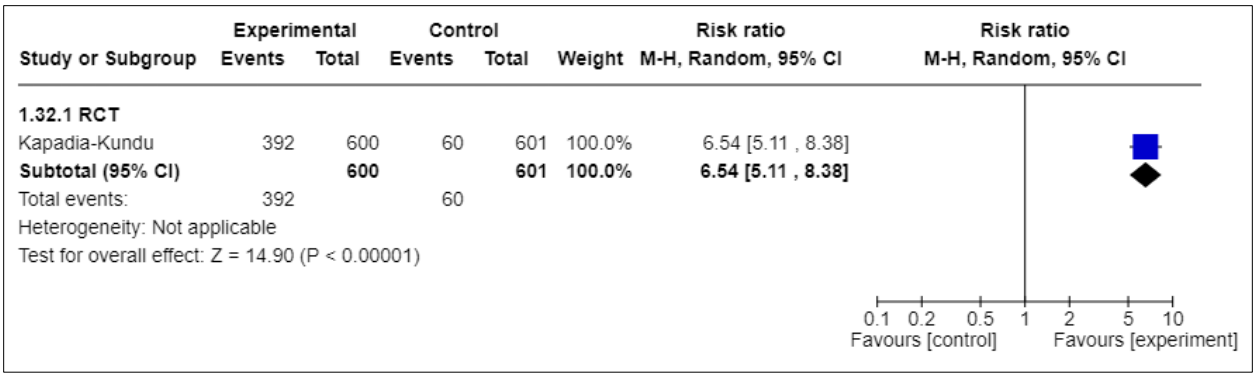


Figure 28. Analysis 25 | Comparison: Complete empowerment model v. Control | Outcome: Annual health check-up (RR).

Deworming tablet consumption

RCTs

One RCT (Kapadia-Kundu 2014) assessed this outcome (study population: 1201 adolescent girls). Our analysis found a significant effect on the consumption of a deworming tablets every six months (RR: 5.33, 95% CI: 4.40, 6.46).

NRS

No NRS assessed this health behaviour.

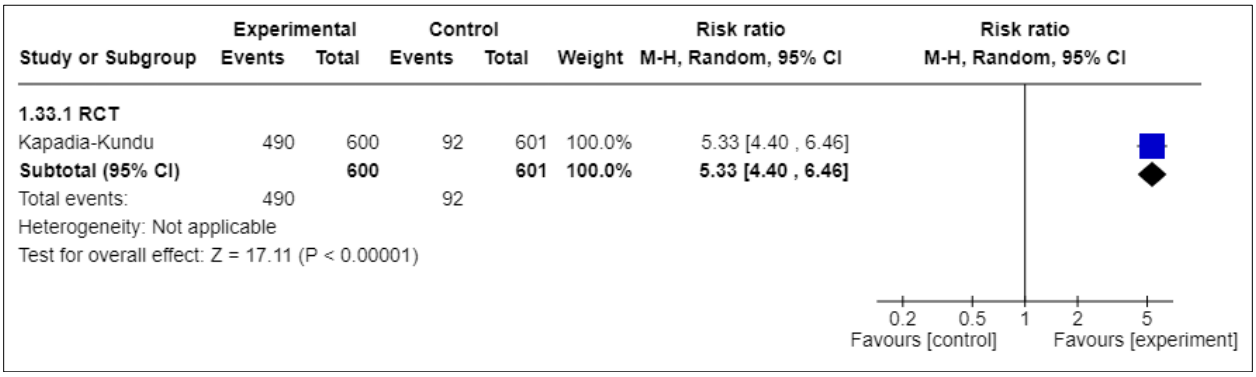


Figure 29. Analysis 26 | Comparison: Complete empowerment model v. Control | Outcome: Consumption of deworming tablet every 6 months (RR).

Breakfast consumption

RCTs

No RCT assessed this health behaviour.

NRS

One NRS (Dehdari 2014) assessed this outcome (study population:100 adolescent girls). Our analysis found a non-significant effect on the weekly frequency of breakfast consumption (MD: 0.90, 95% CI: -0.12, 1.92; very low certainty).

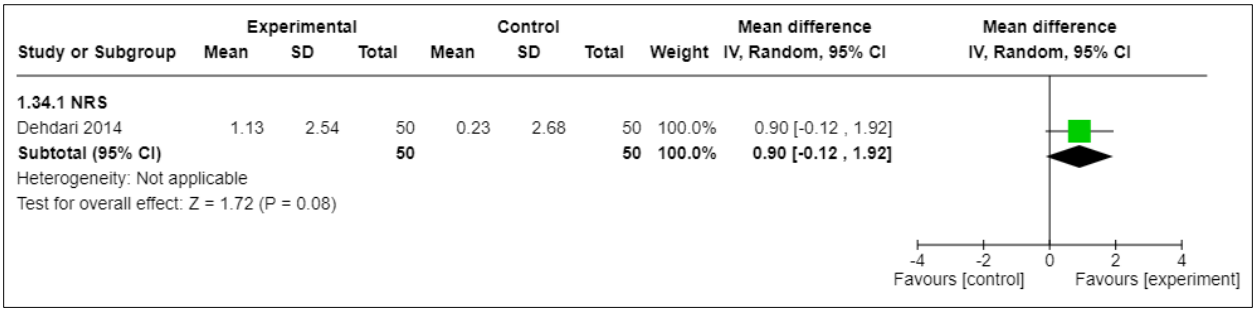


Figure 30. Analysis 27 | Comparison: Complete empowerment model v. Control | Outcome: Breakfast consumption (no. per week).

Results: Contextual and implementation factors

Results of the search

We found one qualitative companion article and one quantitative companion article that assessed implementation or contextual factors for the studies included in our effectiveness analysis.

Included studies

We included two reports (Dunker 2018b, Dunker 2021) that assessed implementation or contextual factors related to the New Moves Brazil programme (Dunker 2018a). The aim of Dunker 2018b was to provide the researchers' perspectives on the barriers and facilitators to adapting and implementing the New Moves program from a high-income to low- and middle-income country context using a case study format. Dunker et al. (2021) provided a quantitative analysis of the association between participation level and eating behaviour among the trial participants.

Excluded studies

We found no other reports assessing implementation or contextual factors pertaining to the studies included in our effectiveness assessment, thus no studies were excluded from this analysis.

Quality assessment of included studies

We appraised the quality of the qualitative study (Dunker 2018b) using the Critical Appraisal Skills Programme (CASP) checklist for qualitative research [61]. The results of the assessment are summarized in Table 6.

Table 6. Quality assessment of Dunker 2018b using the CASP checklist for qualitative research.

	Assessment question	Decision
1	Was there a clear statement of the aims of the research?	Yes
2	Is a qualitative methodology appropriate?	Yes
3	Was the research design appropriate to address the aims of the research?	Cannot tell
4	Was the recruitment strategy appropriate to the aims of the research?	Cannot tell
5	Was the data collected in a way that addressed the research issue?	Cannot tell
6	Has the relationship between researcher and participants been adequately considered?	Cannot tell
7	Have ethical issues been taken into consideration?	Cannot tell
8	Was the data analysis sufficiently rigorous?	Cannot tell
9	Is there a clear statement of findings?	Yes
10	Will the results help locally?	Yes

The quality of the quantitative study (Dunker 2021) was assessed using the Campbell IDCG risk of bias tool to assess the quality of quantitative study designs (Hombrados & Waddington, 2012) (Appendix C).

Synthesis of results

In the following sections we summarize the findings from the included studies (Dunker 2018b, Dunker 2021) according to the implementation and contextual factors outlined in this review's original logic model (Figure 1).

Recruitment

Challenges were identified regarding the recruitment of schools to participate in the trial. They were: lack of interest on the part of school management, lack of time to participate, changes in school management, and limited facilities to host the trial (Dunker 2018b).

Reach, retention, and attrition

The intervention reach was limited. Of the 131 participants enrolled in the intervention arm, 40.5% (53/131) of participants attended more than 10/17 sessions. Twenty-eight percent (37/131) of intervention arm participants did not attend any session. Attendance in the maintenance phase was worse – just 31.1% (32/131) of the intervention arm participants attended five or more sessions (Dunker 2021).

Reasons for low participation included: school location compared to where students lived since students had to return to school for the intervention sessions that were delivered outside of regular school hours; and students' ability to understand the intervention content and stay focused/attentive. Students from troubled neighbourhoods had greater difficulty with reading and attention deficits, and with inconsistent attendance/commitment to the program (Dunker 2018b).

The provision of incentives to participants (e.g., the offer of snacks) was identified as a potential strategy to improve participation (Dunker 2018b).

Dose

No findings.

Fidelity

The intervention content was adapted from a program originally designed for low-income adolescents in the US. The extensive program content was difficult to adhere to because of time limitations and lack of student interest or engagement (Dunker 2018b).

Adaptability

During implementation, the program had to adapt to operating in a low-resource environment. Lack of classroom space, competition for the use of school facilities, and finding alternative materials to use during program sessions (e.g., the use of bags of food as weights for physical activity sessions) were examples of situations that required adaptation (Dunker 2018b).

Setting

The socioeconomic status of participating schools affected program implementation. Low-resource schools had limited facilities and limited ability to monitor or support program activities. Schools that had better management were more likely to adhere to program activities (Dunker 2018b).

Due to government policy, the program had to be delivered outside of school hours, which contributed to low student participation because they had to return to school for program activities (Dunker 2018b).

Provider

Providers needed to be trained to deliver programmes that go beyond traditional, didactic teaching methods. Skills that need to be acquired include managing group dynamics, supporting participants to reflect on program content in a non-judgemental and accepting environment, conducting motivational interviewing, and leading discussions about feelings, beliefs, and perceptions related to food and the social conditions involved in food choices (Dunker 2018b).

Quality

Despite the interest and support of school management, delivery quality was affected by a lack of teacher time to participate and the limited availability of facilities and training materials (Dunker 2018b).

Cultural appropriateness

The original US program had to be adapted to accommodate Brazil's school calendar, to be delivered outside of school hours, and to reflect local food choices. Even with these adaptations, challenges were encountered due to socioeconomic and cultural differences between the contexts. For example, the program emphasized parental engagement, but in Brazil, parents are not as engaged with schools because their children may not attend a school in their local community. Careful consideration about whether a program can be adapted to a local context should be undertaken (Dunker 2018b).

Contamination

No findings.

Cointervention

No findings.

Participant engagement

Participant engagement was a challenge for several reasons: their lack of familiarity with the new teaching methods, such as motivational interviewing; their inexperience with participating in school-related extracurricular activities; and the heavy content of the programme that could be mentally taxing on top of their regular school activities. Participants from communities with high levels of violence had reading and attention deficits that led to inconsistent attendance (Dunker 2018b).

A statistical analysis found no association between participants' level of participation in the program and participants' BMI or eating behaviours (Dunker 2021).

Sustainability

The only activity that continued after the study's conclusion in some participating schools was the physical activity component because it was included in the school curriculum where school management prioritized student health and had the financial resources, infrastructure, and staff to support the activities (Dunker 2018b).

Individual level factors

The socio-cultural profile of the participants made some of the novel content difficult for participants to engage with, e.g., discussions around body image. Lower education levels affected participants' understanding and recognition of the importance of a healthy lifestyle (Dunker 2018b).

Household and community level factors

The socio-economic status of schools and communities affected the quality of program delivery due to limited teacher participation, facilities, and training materials. Participants from communities with high levels of violence has inconsistent participation (Dunker 2018b).

Macro level factors

Food availability and basic insecurity in Brazil presented additional challenges. Food choice, self-care and physical activity were not prioritized in insecure contexts as the content was distant from participants' reality. Food marketing was hypothesized to influence food choice, preferences, and consumption towards energy dense but nutrient poor foods among participants. Manufactured foods, while lower in nutritional value, were also more affordable (Dunker 2018b).

Fostering agency

Addressing issues like body acceptance, media influence, beauty standards, and healthy eating behaviours improved participants' self-esteem and led to a better relationship with food, body satisfaction and reduced disordered eating behaviours (Dunker 2018b).

The response to the use of motivational interviewing was varied among participants. Even when participants were engaged, they had difficulty setting personal goals (Dunker 2018b).

Creating a supportive opportunity structure

Parental engagement in the program was low due to limited parental engagement in schools that are outside of their communities. This affected their ability to encourage their children to participate (Dunker 2018b).

Results: Application of empowerment theory

Theoretical frameworks

Eight studies used theoretical frameworks to inform intervention design. Each study's description of their theoretical framework is provided in Table 7. Three studies (Bagherniya 2017, Leme 2018, Dunker 2018a) applied social cognitive theory (SCT) [94]. One study (Kapadia-Kundu 2014) used the health competence model [95]. Two studies (Dehdari 2014, Dehdari 2016) used Pender's health promotion model [96]. Two studies (Jeijooni 2019, Jeijooni 2021) applied the PRECEDE model [97].

Table 7. Theoretical framework descriptions by study authors.

Study	Theoretical framework description
Alaofè 2009a	None.
Bagherniya 2017	*"One of the most useful theory for school-based program in children and adolescents is **social cognitive theory (SCT)**, which suggests that human behavior is the result of dynamic interaction between personal, behavioral, and environmental factors."* p.38. *"With the aim of making changes in dietary behaviors and gradual reduction in the body weight of study subjects, a school-based intervention by considering evidence-based psychological (i.e., self-efficacy, outcome expectation) behavioral (i.e., knowledge and skills), and environmental (i.e., parents, teachers support, and situation) components was conducted…"* p.38.
Dehdari 2014	*"One of the models used in changing behaviour is **Pender's Health Promotion Model** (HPM). Pender's HPM is an attempt to illustrate the multidimensional nature of individuals interacting with their interpersonal and physical environments as they pursue health(17). The model includes three basic components that influence health-promoting behaviour: (i) individual characteristics and experiences (prior related behaviour and personal factors); (ii) behaviour-specific cognitions and affect (perceived benefits of action, perceived barriers of action, perceived self-efficacy, situational influences, interpersonal influences and activity-related affect); and (iii) desirable health promotion behaviour (commitment to a plan of action and immediate competing demands and preferences)(18). Although Pender's HPM is recommended for improving adolescent behaviour(19), few studies have used this model for promoting healthy behaviour among adolescents(20,21)."* p.658.
Dehdari 2016	*"Hence, in the present study, we used **Pender's Health Promotion Model** (Pender's HPM) as a conceptual framework in designing the content of training sessions. The model has been recommended for diet interventions (Dehdari, Rahimi, Aryaeian, & Gohari, 2014). It includes three main elements that influence health-enhancing behavior: (i) individual variables and experiences; (ii) cognitions and feelings about a behavior; and (iii) favorable health promotion behavior (Pender, Murdaugh, & Parsons, 2002)."* p.192-193.
Dunker 2018a	*"Bandura's **Social Cognitive Theory** provided the primary theoretic framework for New Moves. It states that the people's self-perception must initially change to precipitate behavioral change. To reduce adolescents' eating problems, one must aim to improve*

Study	Theoretical framework description
	their body image by way of promoting their whole self-image and self-esteem. Self-esteem protection and enhancement are, therefore, appropriate and desirable to all adolescents, being particularly relevant in the treatment and prevention of body image and eating problems as well as obesity since low self-esteem is considered to be a potent risk factor for eating problems [26]." p.103-104.
Jeihooni 2019	*"So, employing models for investigating behaviors is recommended and one of the most useable and appropriate models in this field is the* ***precede model****. The constructs of this model are the predisposing factors (individual and social characteristics motivating people for taking healthy behaviors), reinforcing factors (material and spiritual rewards causing the contenuity of healthy behaviors) and enabling factors (environmental factors facilitating healthy behaviors or any skills in individuals) (Jeihooni et al. 2017). In economic and environmental determination and evaluation, predisposing factors are factors which are prior to the changing behavior and they provide motivation for changing behaviors (such as knowledge, attitudes, behaviors and values). Enabling factors are the preparations of behavioral or environmental changing realizing an attitude or environmental politics (such as the availability of sources, protocols and skills). Reinforcing factors are factors that follow behavior and provide continuous rewards for saving a particular behavior (such as families, teachers, managers and health officials) (Jeihooni et al., 2017)."* p.2.
Jeihooni 2021	*"Considering the framework of* ***PRECEDE model****, its constructs; the role of students' knowledge, attitude and self-efficacy, reinforcing factors (family and school authorities), and enabling factors (access to information and educational resources in eating behaviors preventing IDA), we used the PRECEDE model, which has been introduced as a successful model in many clinical and field trials [21, 25]. This model provides a framework by which factors affecting behavior such as predisposing factors (knowledge, attitude, etc.), reinforcing factors (family, peers, etc.), and enabling factors (access to resources, skills, etc.) in the diagnosis of education are identified [27]. The PRECEDE–PROCEED model systematically plans, implements, and evaluates health education activities. It is designed with an ecological approach in interconnected stages and a logical process [21]. PRECEDE–PROCEED consists of nine phases, including four planning phases, one implementation phase, and three evaluation phases. Its main approach is to identify the desired outcome, determine the causes of the desired outcome, and intervene to achieve the desired outcome [21]."* p.2.
Kapadia-Kundu 2014	*"****"Ecological" models*** *usually refer to a continuum off explanatory factors, from individual to cultural that have nested effects. Barriers to individual behavior may occur at the household level, the community level, the service delivery level or the policy level. Socioeconomic conditions, access to food, clean water and other resources; the structure of healthcare delivery systems and the behavior of healthcare providers; the functioning of schools and education systems; social norms and social capital within the community and relationships within the family all may contribute to whether or not a young girl can achieve and maintain health. Therefore, models that address specific barriers and facilitating factors at more than one level in an integrated way have greater chances of success.*

Study	Theoretical framework description
	A key concept in this effort to develop multi-level explanations is health competence. ***Health competence*** *has been defined as "having the knowledge, attitudes, skills and resources to act consistently and appropriately across multiple health behaviors" (Storey et al., 2008; Pollock and Storey, 2012) and therefore goes beyond individual factors (e.g., health knowledge, behavioral intentions or self-efficacy) described in classical behavior change theories such as social cognitive theory (Bandura, 1997), the health belief model (Rosenstock, 1974) and the integrated behavioral model (Monta~na and Kasprzyk, forthcoming, Ch. 6)."* p.171.
Leme 2018	*"The theoretical reference was Bandura's* ***Social Cognitive Theory*** *(SCT) 12,13. Intervention components were developed using taxonomy of behavior change strategies 14 and designed to target potential mediators of behavior change in nutrition and [physical activity]."* Leme et al. 2015. p.1384.
Sabet Sarvestani 2009	None.

Definitions of empowerment

No studies provided a definition of empowerment.

Operationalization of empowerment

No studies described an approach to operationalizing empowerment.

Results: Intervention effects on empowerment

Six studies (Bagherniya 2017, Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021, Leme 2018) assessed self-efficacy, a concept closely related to empowerment [98]. Bagherniya et al. (2017) adapted a questionnaire for social cognitive measures related to adolescent dietary behaviours [99]. The adapted scale included seven questions about self-efficacy using a 6-point Likert-type scale (1 = strongly disagree, 6 = strongly agree; score range: 7 to 42). Leme and colleagues also adapted the Dewar et al. (2012) scale and defined self-efficacy as "confidence in the ability to overcome barriers to adopt and maintain healthy behaviors" [100]. They used a 5-item self-efficacy Likert-type scale (1 = strongly disagree, 6 = strongly agree; score range: 5 to 30). Dehdari et al. (2014) created a self-administered questionnaire based on the Health Promotion Model [101]. Eight items were used to measure perceived self-efficacy measured on a 5-point Likert-type scale (1 = completely unconfident, 5 = completely confident; score range: 8 to 40). Dehdari et al. (2016) similarly used the HPM to create a 10-item scale for perceived self-efficacy on a 5-point Likert-type scale (1 = strongly unconfident, 5 = strongly confident; score range: 10 to 50). Jeihooni and colleagues (2019) developed a questionnaire using the PRECEDE model [97]. Self-efficacy was measured by a 10-item questionnaire using a 5-point Likert-type scale (0 = not at all, 4 = very much; score range: 0 to 40). Jeihooni et al. (2021) also developed a questionnaire based on the PRECEDE model. The self-efficacy scale included 15 items and were measured on a 5-point Likert-type scale (1 = completely disagree, 5 = completely agree; score range: 15 to 75).

Self-efficacy

RCTs

Two RCTs (Bagherniya 2017, Leme 2018) assessed this outcome. Our analysis found a non-significant effect on self-efficacy (SMD: 1.05, 95% CI: 0.81, 1.26; low certainty).

NRS

Four NRS (Dehdari 2014, Dehdari 2016, Jeihooni 2019, Jeihooni 2021) assessed this outcome. We found substantial heterogeneity (I^2 = 99%) and the data were not meta-analyzed. Our analysis of Dehdari 2014 found a significant effect on self-efficacy (SMD = 0.47, 95% CI: 0.08, 0.87; very low certainty). Our analysis of Dehdari 2016 also found a significant effect on self-efficacy (SMD = 0.41, 95% CI: 0.08, 0.74; very low certainty). Our analysis of Jeihooni 2019 found a significant effect on self-efficacy (SMD = 6.31, 95% CI: 5.63, 6.31; very low certainty). Our analysis of Jeihooni 2021 found a significant effect on self-efficacy (SMD: 5.61, 95% CI: 4.92, 6.31; very low certainty).

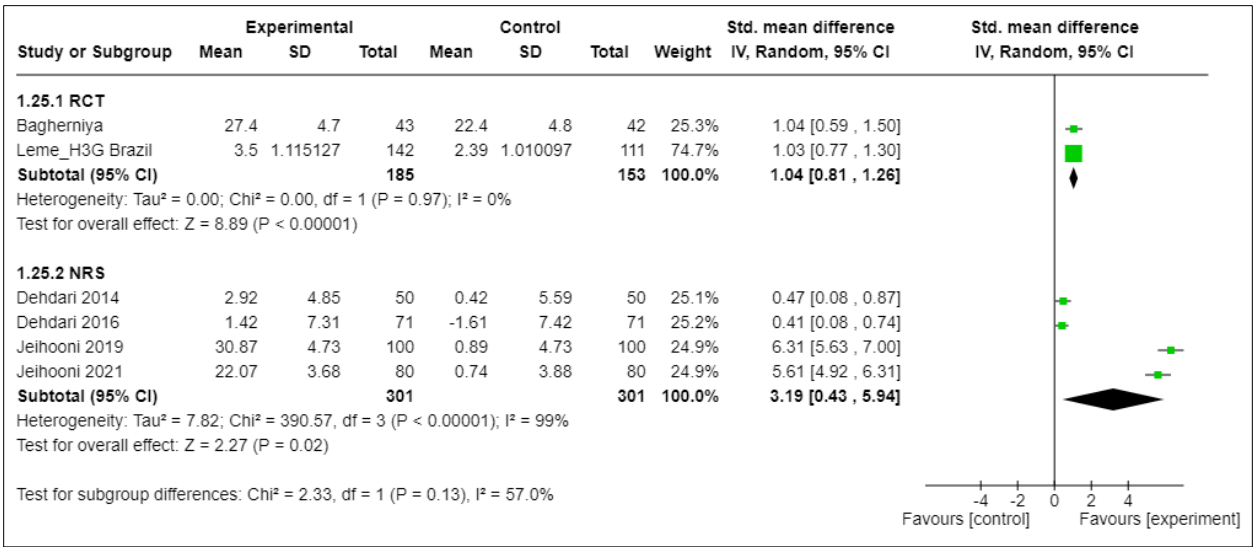


Figure 31. Analysis 27 | Comparison: Complete empowerment model v. Control | Outcome: Self-efficacy (SD).

Results: Adverse effects

One study (Dunker 2018a) assessed potential harms. They reported no harm or unintended effects were observed in either group that could be directly attributed to the intervention.

Results: Revised logic model

Figure 34 presents a revised logic model based on this review's quantitative and qualitative syntheses. Based on our findings, we expanded the descriptions of the activities and outputs that contribute to an empowerment-based approach, identified important implementation and moderating factors for intervention success, and clarified the impact pathways between the concepts outlined in the logic model. We included the nutrition outcomes that were measured in the effectiveness assessment, regardless of whether our analysis found a significant effect of the intervention on the measured outcome. Finally, we removed concepts from the original logic model that we did not identify through our review. We recognize that these elements may still be important concepts to consider in the design, implementation, and evaluation of empowerment-based nutrition interventions for adolescent girls, but we sought to summarize our findings using this logic model, as opposed to it serving as a full conceptual model for empowerment-based nutrition interventions. In the following sections we describe the concepts presented in the revised logic model.

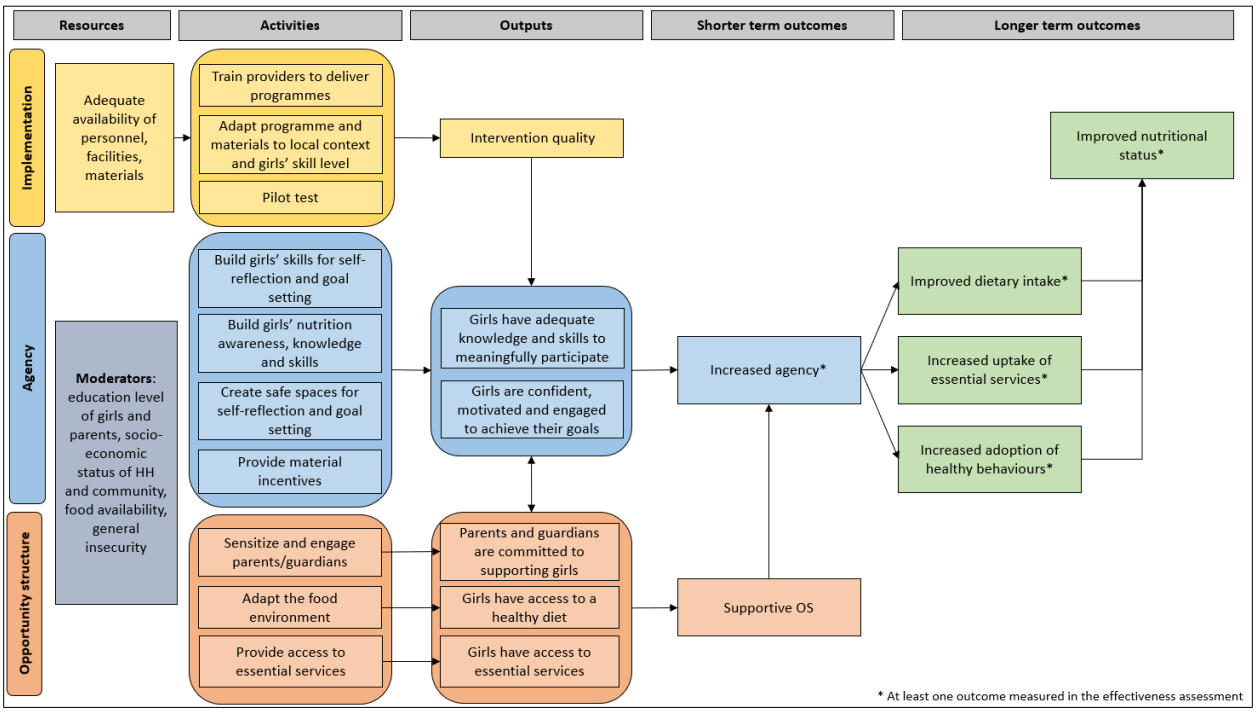


Figure 32. Revised logic model of the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status.

Implementation activities

Under the resources category, we highlight the need for adequate personnel, facilities, and materials to support effective implementation, but resource availability alone is insufficient. Personnel must receive training to apply empowerment-related concepts, such as motivational interviewing, in their engagement

with adolescent girls. Intervention content and delivery strategies may need to be adapted to the local context and girls' skills levels. Pilot testing of the intervention and its associated materials is an important step in the adaptation process.

Activities to foster agency

We identified four main activities that are used to foster adolescent girls' agency:

(a) Building skills for self-reflection and goal setting

In some instances, the concepts of self-reflection and goal setting may be foreign to participants, and they will need support from intervention providers to increase their capacity to undertake these processes for themselves.

(b) Increasing nutrition-related awareness, knowledge, and skills

Adolescent girls will also need to be supported to increase their awareness of the importance of proper nutrition and the adoption of healthy behaviours, the knowledge of what a healthy diet and lifestyle entails, and the skills to obtain adequate nutrition for themselves (e.g., through advocacy with parents and guardians, cooking skills, etc.).

(c) Creating safe spaces for self-reflection and goal setting

Alongside building girls' skills for self-reflection and goal setting is the need to create safe spaces for them to exercise these skills. A key component of this activity is training intervention providers to create and maintain safe spaces for participants to reflect and develop plans for action to improve their own nutrition. This requires a shift from a didactic to a facilitative teaching approach that is collaborative, reflective, and inquiry-focused [102].

(d) Providing material incentives

Maintaining participant engagement can be supported by the provision of material incentives, such as free meals, snacks, or gifts (pens, notebooks, etc.)

Activities to create a supportive opportunity structure

We identified three activities that can contribute to creating a supportive opportunity structure that empowers girls for improved nutrition:

(a) Sensitive and engage parents and guardians

A consistent approach across all of the included studies was engaging parents, and less frequently, teachers, to support adolescent girls' to adopt healthier eating and lifestyle practices. Engagement approaches can be active, such as holding sensitization sessions for parents or including them in intervention activities alongside their children, or passive, such as sending information pamphlets home to inform parents about the intervention's objectives and activities.

(b) Provide access to a healthy diet

Creating a supportive opportunity structure can also include changing the food environment for adolescent girls to support healthier choices. This can be done by working with parents to adjust what foods are available at home, or changing the foods available at school through cafeterias, snack machines, etc.

(c) Provide access to essential services

A final activity we identified was improving girls' access to essential services, such as providing access to health care, sexual and reproductive health services, or micronutrient supplementation through the school.

Output level

At the output level, we propose that the implementation-related activities will to intervention quality, which will influence the outputs of the agency- and OS-related activities. Specifically, for the agency-related activities, we anticipate that adolescent girls would have improved knowledge and skills to meaningfully participate in the intervention, and increased self-confidence, motivation, and engagement in the intervention to achieve their goals. As a result of OS-related activities, we propose that parents and guardians will be more committed to supporting their children and the intervention's goals, and girls will have improved access to a healthy diet and essential services.

Outcome level

Following along the causal chain, we propose that the combination of outputs would lead to the establishment of a supportive OS for girls' empowerment and improved nutrition and increased agency (i.e., the ability to set and achieve goals) among adolescent girls. Their increased agency would then translate into actions that improve their dietary intake, increase their uptake of essential services, and their adoption of healthy behaviours. And in the longer term, adolescent girls would experience an overall improvement in their health and nutrition status.

Intervention moderators

We identified moderators at the individual, household, and community levels that may influence intervention effectiveness. At the individual level, girls' level of education can affect the extent to which they can understand and apply the concepts conveyed through the intervention. At the household parents' level of education can similarly affect their engagement in the intervention and their ability to support their children's participation and success. The household's socioeconomic status can further affect the availability of parents to participate in the intervention due to constraints on their time, and the resources available in the household for food or health services. The community's socioeconomic status can affect the availability and quality of the facilities (e.g., schools) or other resources available for the intervention's successful implementation. Also at the community level, general insecurity can deprioritize intervention participation or the relative importance of a healthy diet in comparison to concerns about safety and security.

What we did not find

There were some concepts in our original logic model that we did not find evidence for in this review. They include evidence of any adverse effects of empowerment-based nutrition interventions, measures for adolescent girls' decision-making power, resource/access control, or rights protection and fulfilment, and measures related to risk of illness, disease, or early/unwanted pregnancy.

Discussion

Summary of main results

We synthesized ten studies that met our inclusion criteria for this review. We found limited, low-quality evidence that empowerment-based nutrition interventions improve adolescent girls' nutritional status. Our analysis of included RCTs showed a non-significant effect on BMI and waist circumference among adolescent girls living in middle-income countries (MICs) (low to very low certainty). Our analysis of NRS found significant effects of empowerment-based nutrition interventions on reducing BMI, waist circumference, and arm circumference among adolescent girls living in MICs; however, the included studies had a high risk of bias, and we have very low confidence that these results demonstrate the true intervention effect. We did not find any studies that assessed BMI or other anthropometric measures among adolescent girls in low-income countries.

Two NRS that assessed intervention effects on haemoglobin found a significant positive effect (very low certainty), but they could not be meta-analysed due to substantial heterogeneity among studies, likely due to their different populations and settings. Alaofè 2009a was conducted in boarding schools in south

Benin, where a high prevalence of anemia among adolescent girls persists [103]. All study participants had mild iron deficiency anemia at the study outset. In contrast, Jeihooni 2021 was conducted among adolescent girls with no pre-existing medical conditions attending public school in Fasa City, Iran. Our analysis of the studies showed a significant effect of empowerment-based nutrition interventions on adolescent girls' haemoglobin levels in both settings, but the certainty level of this finding is very low due to the studies' moderate to high risks of bias, substantial heterogeneity, and small sample sizes. Similarly, we have very low certainty that empowerment-based nutrition interventions improve anemia status and serum ferritin based on evidence from one NRS with a moderate risk of bias and small sample size.

We found limited evidence that empowerment-based nutrition interventions significantly affect dietary intake (low to very low certainty), but the evidence base was limited by small sample sizes and substantial heterogeneity. The preponderance of evidence we found on macro- and micronutrient intake came from three NRS, two of which were conducted in Iran (Dehdari 2014, Dehdari 2016) and one in Benin (Alaofè 2009a). We did not conduct a meta-analysis for several of these outcomes due to high heterogeneity among studies. The study conducted in Benin consistently showed greater effects on macro- and micronutrient intake compared to the studies conducted in Iran (except for vitamin A). We hypothesized that differences in the studies' interventions and settings contributed to this difference. Specifically, the Benin study included an OS component that altered the food environment by revising school menus, making healthier foods more convenient and limiting access to unhealthy foods for adolescent girls residing in the participating boarding schools. These girls would have had less opportunity to choose unhealthy foods compared to girls who attend school but live at home. In contrast, the OS components in the Iranian studies only included parental sensitization efforts and participants lived at home, thus even if study participants wanted to improve their diet, there was no guarantee that their food environment would improve to accommodate that decision.

When examining dietary intake using self-reported measures of food group servings, most evidence came from two RCTs conducted in Iran (Bagherniya 2017) and Brazil (Leme 2018). There is some evidence that empowerment-based nutrition interventions may reduce the intake of sweets (low certainty) and junk food (very low certainty) and increase fruit and vegetable consumption (low certainty). In some cases, these studies did not measure the same food serving types (e.g., one study measured fruit and vegetable servings as a combined outcome while the other measured them as two separate outcomes), making it difficult to meta-analyze the results; and there was substantial heterogeneity when both studies measured the same outcome. In these instances, the Iranian study produced greater effect sizes while the Brazilian study often found no significant intervention effect. One variation in the interventions that may explain the difference in outcomes is the more active engagement of parents in the Iranian study including their

participation in workshops, visits to industrial food companies, and sensitization sessions. The Brazilian study only engaged parents through newsletters. It may be that the active engagement provided parents with the additional knowledge and skills to better support adolescent girls to make healthier dietary choices.

We found evidence from one RCT conducted in India that empowerment-based nutrition interventions may lead to improved health behaviours, including IFA and deworming tablet consumption, annual health checks, greater dietary diversity, and increased consumption of certain foods (e.g., sprouted legumes) (moderate certainty). One NRS conducted in Iran showed a significant increase in breakfast consumption among intervention participants, but the certainty of evidence was very low.

Two RCTs and four NRS all found a significant positive effect of empowerment-based nutrition interventions on adolescent girls' self-efficacy (low to very low certainty). The lack of a standardized tool to measure concepts related to empowerment presents a challenge to fully understanding the ways in which empowerment-based nutrition interventions translate into increased agency and empowerment among participants and prevents effective comparisons across studies.

None of our included studies employed the term "empowerment." Instead, we had to identify empowerment-based nutrition interventions based on the presence of activities to foster agency and create a supportive OS. We found that interventions that met our inclusion criteria most often employed a behaviour change theory that includes traits related to the concept of empowerment. For example, social cognitive theory puts forth that human behaviour is a result of the interaction between a person, their environment and behaviour. The SCT constructs of self-efficacy (a person's confidence in her or his ability to successfully perform a behaviour) and behavioural capability (a person's actual ability to perform a behavior through essential knowledge and skills) align with the concept of agency in empowerment theory, while the SCT concept of reinforcements (internal or external responses to a person's behavior that affect the likelihood of continuing or discontinuing the behavior) aligns with the concept of opportunity structure. SCT seeks to support goal-directed behaviour, much as empowerment theory seeks to support women and girls to make strategic life choices and achieve their goals. While we can gain valuable lessons from studies that employ concepts closely related to empowerment, as we have tried to do here, there is a need to undertake high quality research that explicitly aims to test empowerment models.

We identified two companion articles that assessed the influence of implementation or contextual factors on the effectiveness of empowerment-based nutrition interventions for adolescent girls. Both articles were related to one RCT (Dunker 2018) that was included in this review's effectiveness assessment. The one

qualitative study we identified provided the perspective of the study's administrators (researchers) on the barriers and facilitators to adapting and implementing a multi-component obesity prevention program from a high-income country (United States) to a middle-income country context (Brazil). The second article was a statistical analysis of the association between participant engagement and study outcomes. Implementation factors that may contribute to intervention success include adapting the intervention to the local context and culture, training intervention providers, ensuring adequate availability of personnel, facilities, and materials, providing material incentives to adolescent girls to encourage participation, tailoring content to the education level of the participants, and pilot testing the intervention. Contextual factors that may affect intervention success are the socio-economic status of the community, food availability, and general insecurity. We mapped and summarized the findings from the companion reports to the components of our logic model. We then updated our logic model based on the results of this review. Based on our findings, we expanded the descriptions of the activities and outputs that contribute to an empowerment-based approach, identified important implementation and moderating factors for intervention success, and clarified the impact pathways between the concepts outlined in the logic model.

Overall completeness and applicability of evidence

Most of the studies included in the review were conducted in upper middle-income countries (Iran, Brazil) and addressed nutritional challenges related to overnutrition, such as overweight and obesity; only two studies were conducted in countries where undernutrition (including micronutrient deficiencies) remains a primary concern (Benin, India). While the nutrition transition is highly impactful on adolescents globally [7], there remains a need to understand the role of empowerment-based nutrition programming on adolescent undernutrition as well.

All studies were conducted in a school setting which leaves a gap in our understanding of the effectiveness of empowerment-based nutrition programmes conducted in other settings, such as the community. Only targeting adolescent girls who are in school leaves out an important segment of this age group who may be at even greater risk of disempowerment and malnutrition [104,105].

We identified a further 13 studies that met our inclusion criteria regarding the intervention, outcomes, and comparators, but because the study authors did not disaggregate their results by sex, we could not include them. We reached out to study authors to request sex-disaggregated data and we hope to include these studies in a future update of the review.

We found only two companion articles assessing implementation and contextual factors of the included studies. Consequently, there were some concepts in our original logic model that we did not find evidence for in this review. They include evidence of any adverse effects of empowerment-based nutrition

interventions, measures for adolescent girls' decision-making power, resource/access control, or rights protection and fulfilment, and measures related to risk of illness, disease, or early/unwanted pregnancy. These are potentially important elements of a complete causal chain to evaluate the effectiveness of empowerment-based nutrition interventions that need to be evaluated in future research.

Quality of the evidence

We included two RCTs rated as low risk of bias, one RCT rated at unclear risk of bias (due to unclear outcome reporting) and one RCT at high risk of bias (due to concerns about selection bias and confounding). Five out of six NRS were rated as high risk of bias due to the high risk of selection bias and confounding, concerns about group equivalence, and high risk of bias for analysis reporting. The sixth NRS was rated as having an unclear risk of bias (due to unclear risk of selection bias and confounding and unclear group equivalence).

The quality of the evidence was rated to be moderate to very low (Appendix D). The outcome quality was downgraded due to study limitations, including unclear sequence generation and allocation concealment methods, lack of blinding, high heterogeneity, and imprecision.

Potential biases in the review process

This type of review requires authors to make several subjective judgements regarding study eligibility and risk of bias; other authors may have made different decisions. We have tried to minimize the risk of bias by conducting several steps in the review process in duplicate by two independent assessors including: (1) assessments of study eligibility, (2) data extraction, and (3) assessments of risk of bias and evidence quality.

Agreements and disagreements with other studies or reviews

To our knowledge, this is the first systematic review to examine the effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in LMICs. The results of recent systematic reviews of interventions to treat overweight and obesity in adolescents are equivocal. A Cochrane review of diet, physical activity, and behavioural interventions to treat overweight or obese adolescent similarly found low quality evidence of multidisciplinary interventions to reduce BMI, mainly when compared with no treatment or waiting list controls [106]. In contrast, Moores and colleagues reviewed community-based interventions for the treatment of adolescents with overweight and obesity and found significant reductions in BMI and improvements in self-esteem/self-efficacy in three out of four studies that measured the outcome [107]. Both reviews drew on research from high-income countries only. An article summarizing strategies and interventions for healthy adolescent growth, nutrition and

development reported that health interventions that combine, dietary, physical activity and behavioural strategies with family have the potential to reduce overweight and obesity in adolescents, but we did not find evidence of this in our review [108].

A 2020 systematic review of the effects of preventive nutrition interventions among adolescents on health and nutritional status in low-and middle-income countries found limited evidence of the effectiveness of micronutrient supplementation/fortification among adolescents on health and nutritional status in LMICs, with lack of evidence on nutrition education and counselling and macronutrient supplementation [109]. Our review identified several studies that employed nutrition education and counselling as part of an empowerment-based approach, and only one study that included micronutrient supplementation. There may be an opportunity to employ empowerment-based approaches in micronutrient supplementation programs for adolescent girls in LMICs.

Authors' conclusions

Implications for practice

The evidence on empowerment-based nutrition interventions to improve the nutritional status of adolescent girls in LMICs is inconclusive and definitive implications for practice cannot be drawn. The existing evidence base is largely limited to assessing interventions to prevent or treat obesity among adolescent girls in middle-income countries.

Implications for research

Future studies assessing empowerment-based nutrition interventions among adolescents should focus on assessing the effectiveness of interventions in low-income countries where challenges related to undernutrition remain prominent. Studies should also be undertaken in the community and other non-school settings. Studies that target boys and girls should sex-disaggregated their results and reporting. Study quality needs to be improved with careful attention to managing selection bias and confounding, blinding assessors and analyses, and transparent outcome and analysis reporting. Further study of the implementation and contextual factors that contribute to intervention success is needed. Finally, standardized tools and measures for dietary intake, health behaviours, and empowerment are needed.

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Appendix A: Medline search strategy

1. "power (psychology)"/
2. self efficacy/
3. personal autonomy/
4. self concept/
5. (Empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 percept*) or (self adj2 esteem) or (women* adj2 right*) or (women* adj2 status)).tw.
6. 1 or 2 or 3 or 4 or 5
7. MALNUTRITION/
8. OVERNUTRITION/
9. OBESITY/
10. Growth Disorders/
11. (Nutrition* or malnutrit* or undernutrition or (under nutrition) or overnutrition or (over nutrition) or obesity or stunting or wasting or underweight or (under weight) or overweight or (over weight) or malnourish* or (nutrition* adj2 deficienc*)).tw.
12. Feeding Behavior/
13. DIET/
14. MICRONUTRIENTS/
15. VITAMINS/
16. (Micronutrient* or (iron adj4 supplement*) or folate or folic acid or (folic adj4 supplement*) or (iron adj2 folic) or (iron adj2 folate) or vitamin*).tw.
17. ((Nutrition* adj3 education*) or (nutrition adj3 counsel*)).tw.
18. ((food adj2 supplement*) or (food adj3 fortif*)).tw.
19. (school adj2 feed*).tw.
20. Diet*.tw.
21. 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
22. 6 and 21
23. Developing Countries/
24. Africa/ or Asia/ or Caribbean/ or West Indies/ or South America/ or Latin America/ or Central America/
25. (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius

or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).tw.

26. exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/

27. ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world or state*)).tw.

28. ((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj econom*).tw.

29. (low* adj (gdp or gnp or gross domestic or gross national)).tw.

30. (low adj3 middle adj3 countr*).tw.

31. (lmic or lmics or third world or lami countr*).tw.

32. transitional countr*.tw.

33. 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32

34. 22 and 33

35. WOMEN/

36. Female/

37. (woman or women or female* or girl* or matern* or mother* or wife or wives).tw.
38. 35 or 36 or 37
39. 34 and 38

Appendix B: Data extraction codebooks

Quantitative study data extraction form

Extractor name and date		
Citation information	**Author and year**	
	Full citation	
	Parent study	
Contextual factors	**Geographical**	Ex: country, geography, climate, human land use, access to healthcare
	Epidemiological	Ex: Incidence, prevalence, spatial distribution, life expectancy, population density, family size
	Socio-economic	Ex: SES, income, occupation, living conditions, burden of disease
	Socio-cultural	Ex: Language, means of communication, values, symbols. religion, lifestyle, discrimination
	Political	Ex: political system, distribution of power, political stability, violence, corruption, ideology
	Legal	Ex: norms, values underlying legislation, regulations, guidelines,
	Ethical	Ex: autonomy, moral distress, privacy, conflicting interests. morality
Methods	**Objective**	What was the study aim or research question?
	Study design	RCT, CBA, ITS
	Relevant details of study design	For RCTs, randomization, allocation, blinding, etc. For NRS, controls for confounding, analysis, etc.
	Target population	e.g., pregnant women of reproductive age and their infants
	Recruitment and sampling procedures	
	Sample size at baseline (total and per study arms)	
	Setting	Physical location, e.g., health facility, school, workplace
	Participant eligibility criteria	Inclusion and exclusion criteria

	Participant baseline characteristics	Include relevant PROGRESS+ characteristics: Place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, SES, social capital, personal characteristics associated with discrimination (e.g., age, disability, sexual orientation or identity)
	Differences in baseline characteristics	
	Study duration	
Intervention	**Name of intervention**	
	Description of the intervention	
	Theoretical model	e.g., Health Belief Model, Theory of Planned Behavior, Social Cognitive Theory
	Description of the comparison intervention	
	Administrator	
	Provider	Intervention provider and any training they were provided
	Needs assessment/formative research	Description of any prior needs assessment or formative research to inform intervention design
	Cultural sensitivity	Activities undertaken to design the intervention in a culturally sensitive manner
Outcomes	**PRIMARY outcomes reported by study**	E.g., BMI, weight, MUAC, dietary diversity
	Instruments used and scale interpretation	E.g., Dietary diversity score (DDS). Food groups considered were cereals/roots, vegetables, fruits, legumes/lentils, meat/fish/egg & milk/dairy products. If an individual eate any quantity of any food group at least once per day, it was taken into count. Include any authors comments on measure validity or reliability
	Timing of outcome measurements	E.g., baseline, 6 months, 12 months
	Adverse outcomes reported by authors	E.g., gender-based violence, consumption of sugar sweetened foods or beverages
	SECONDARY outcomes reported by study	E.g., self-efficacy, dietary intake, depressive symptoms

	Instruments used and scale interpretation	E.g., Dietary diversity score (DDS). Food groups considered were cereals/roots, vegetables, fruits, legumes/lentils, meat/fish/egg & milk/dairy products. If an individual eate any quantity of any food group at least once per day, it was taken into count. Include any authors comments on measure validity or reliability
	Timing of outcome measurements	E.g., baseline, 6 months, 12 months
	Statistical analyses	
Results	**Participant follow-up**	How many participants [in each group] completed the study? Was drop-out balanced between intervention and control groups? Were losses more common for a particular PROGRESS+ characteristic?
	Summary data - binary NUTRITION outcomes	Intervention group sample size
		Intervention group number of events
		Control group sample size
		Control group number of events
	Summary data - continuous NUTRITION outcomes	Mean
		Variance of mean (measure of variance, standard deviation or 95%CI)
	Between-group estimates	For RCTs or NRSI, this could be OR, Log OR, RR, Log RR, MD, SMD. Always include 95%CI
	Summary data - binary EMPOWERMENT outcomes	Intervention group sample size
		Intervention group number of events
		Control group sample size
		Control group number of events
	Summary data - continuous EMPOWERMENT outcomes	Mean
		Variance of mean (measure of variance, standard deviation or 95%CI)
	Between-group estimates	For RCTs or NRSI, this could be OR, Log OR, RR, Log RR, MD, SMD. Always include 95%CI
Implementation factors	**Reach**	The proportion of participants who attend sessions or have exposure to various program elements.
	Dose	Frequency, intensity and duration of intervention delivery to participants

	Fidelity	Degree to which the intervention was delivered according to original design
	Adaptation	Adaptation during implementation to respond to changing circumstances
	Co-intervention	Unintentional delivery of another intervention to study population
	Contamination	Unintentional delivery of intervention to comparison group or failure to provide intervention to intervention group
	Engagement	Active participation and receptivity to the intervention
	Quality	Quality of intervention materials and resources
	Contribution of agency component to intervention results	As described by authors
	Contribution of OS component to intervention results	As described by authors
Other	**Main conclusions**	
	Study strengths	As described by authors
	Study limitations	As described by authors
	Funding	
	Conflicts of interest	
	Ethics	
	Extractor comments	

Qualitative study data extraction form

Code	**Extraction**
Extractor name and date extracted	
Full citation	
First author and year	
Type of publication	
Parent study	
Study aim(s)	
Study duration	
Study start date	

Study end date	
Study design description	
Recruitment strategy	
Study analysis approach	
Study perspective	
Study participant inclusion criteria	
Study participant exclusion criteria	
Number of participants	
Participant age range	
Participant characteristics according to PROGRESS+	
Study setting	
Study conclusion	
Study strengths	
Study limitations	
Implementation factors	
Recruitment	
Retention	
Attrition	
Reach	
Dose	
Fidelity	
Adaptability	
Delivery platform	
Setting	
Provider	
Quality	
Cultural appropriateness	
Contamination	

Cointervention	
Participant engagement	
Short term outcomes	
Motivation to improve nutrition behaviours	
Knowledge and/or skills for improved nutrition behaviours	
Supportive home environment for girls' agency and/or nutrition	
Supportive community environment for girls' agency and/or nutrition	
Intermediate outcomes	
Girls' agency and decision-making power for improved nutrition	
Girls' access to and control over resources for improved nutrition	
Protection and fulfilment of girls' human rights	
Access to a healthy diet	
Use of essential health services	
Adoption of healthy behaviours	
Longer term outcomes	
Improved dietary intake	
Reduced risk of illness and disease	
Reduced risk of early or unwanted pregnancy	
Adverse effects	
Improved health or nutritional status	
Contextual factors	
Individual level	
Household/community level	
Macro-level	
Other	

Appendix C: Risk of bias assessments

Quantitative studies

Alaofè 2009

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	Unclear. The schools were not purposely selected from among six boarding schools located in six different departments of Benin. Multivariable analysis was conducted controlling for baseline covariates (age, religion, parents' level of education, and baseline knowledge of food sources).
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	Unclear. The multivariable analysis included baseline covariates (age, religion, parents' level of education, and baseline knowledge of food sources) but potential confounders may be omitted. Some baseline difference between groups. "The baseline results revealed no significant differences between the intervention and control groups in age, BMI, use of supplements during the past month, religion, parents' occupation, and household size. The majority of the parents in both groups were literate. A higher proportion of mothers of girls in the intervention group had a secondary or university degree than mothers of girls in the control group (p = .03), and more fathers of girls in the intervention group had a university degree than fathers of girls in the control group (p = .005)." No losses to follow-up but 4 participants in the control group were eliminated randomly to have equal number of participants between groups. Without knowing whether the eliminated participants were similar the rest of the group, the impact is unclear.

Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a study/trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Yes. The two schools were located 70km apart.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	Yes. Appropriate methods of estimation applied. "Statistical analyses were performed with NCSS 2004 and SAS software [35]. Sociodemographic characteristics of the two groups and the percentages of subjects with iron status indicators below the cutoff values were compared by the chi-square test. The independent samples t-test (two-tailed) was used to compare group means for iron status indicators. A two-way analysis of variance with repeated measures was used to study the effect of the factor group (intervention vs. control) on the evolution of each nutrient. The repeated factor was the period. The linear mixed procedure of the SAS program [35] was used with a repeated statement and the covariance structure that minimizes the Akaike criterion. When assumptions of normality and homogeneity of variance were not met, the logarithmic or square transformations were used. Pairwise comparisons were made by using Fisher's LSD (least significant difference) protected. Serum ferritin had a skewed distribution; therefore, this value was log transformed for all statistical calculations. Differences between the two groups in knowledge scores and percentages of subjects with iron status indicators below the cutoff values were assessed by the McNemar test. Changes in means of iron status indicators within groups over time were assessed by paired t-tests. Analysis of covariance (ANCOVA) was used to compare means of iron status indices between the two groups. The covariates studied were age, religion, parents' level of

	education, and baseline knowledge of food sources of vitamin C. Finally, logistic regression analysis was used to determine whether there were differences between the groups in the prevalence of anemia, iron deficiency, iron deficiency anemia, malaria, and intestinal parasitic infections (dependent variables). Logistic regressions were adjusted for age and baseline values cited above. Statistical significance was set at $p < .05$."
Other Was the study free from other sources of bias?	Unclear. Assessors not blinded. Self-reporting of dietary intake subject to bias.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Yes. "A sample of 32 girls in each boarding school was required to show a statistically significant difference in the prevalence of iron-deficiency anemia between groups with a power of 80% and $\alpha = 0.05$ [13]."

Bagherniya 2017

Criteria	**Assessment**
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	Unclear. Method of sequence generation not described. Allocation concealment not described. GLM analysis of repeated measures with covariate adjustments for baseline measures and potential confounders. Participant recruitment took place after randomization (see participant flow chart p38)
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	Unclear. GLM analysis of repeated measures with covariate adjustments for baseline measures and potential confounders.

	There were significant differences in BMI and waist circumference between treatment and control groups at baseline. At the end of the study, the intervention arm had more losses to follow-up, e.g., 12 intervention groups participants refused to be measured vs. 3 control group participants.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address the subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. Reported outcomes match those listed in the study protocol https://www/irct.it/trial/14540
Selective analysis reporting Was the study free from analysis reporting bias?	Yes. "All data were analyzed through Statistical Package for the Social Sciences (SPSS), version 18, at significant level of less than 5%. Differences between two groups at baseline, middle, and the end of study were assessed by an independent t test. For psychosocial variables, General Linear Model Univariate analysis was used to assess differences between the two group outcomes controlling baseline values of these variables and potential confounders, with the SCT constructs at the end of study as dependent variables and groups as the fixed factor. General Linear Model analysis of repeated measures was selected to assess differences between two groups, follow- up in three times (baseline, middle, and end of the study) and the interaction between intervention group and time of follow-up with covariate adjustments for baseline values and for the potential confounding factors including age, and sociodemographic factors.

	The between-subjects factor was groups (intervention and control) and the within-subjects factor was BMI, WCs, and nutritional behaviors." ITT analysis - see CONSORT flow chart.
Other Was the study free from other sources of bias?	Yes. Assessors were blinded to group allocation. Self-reporting of secondary variables (dietary intake and psychosocial variables) subject to bias.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	No. Clustering not accounted for in the analysis. Small sample size.

Dehdari 2014

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	No. Recruitment and randomization not adequately described. "The study was carried out among 100 female middle-school students in Qom, Iran, during April–June 2011. Given the estimated sample size, two middle schools were randomly selected. Then, fifty students were randomly selected from each school and assigned to the experimental group (recipient of classroom nutrition education plus designed nutrition education based on Pender's HPM) or the control group (recipient of classroom nutrition education). Participant selection was based on a small convenience sample. No multivariable analysis to control for baseline covariates.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	No. No multivariable analysis. Analyses before and after the intervention were conducted using Student's paired-samples t-test. No losses to follow-up.

	No significant differences in baseline characteristics. "…no significant differences were found between the two groups for any of the demographic characteristics, Pender's HPM constructs, and the weekly frequency or the nutrient intake of breakfast consumption."
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	No. No multivariable analysis conducted.
Other Was the study free from other sources of bias?	No. Primary outcomes were self-reported. Unclear whether assessors or analysis were blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	No. Small sample size. No sample size calculation provided.

Dehdari 2016

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	No. Recruitment and randomization not adequately described. "First, two middle schools were randomly selected. In the next step, 71 female students in the 7th grade were selected from each school and then allocated to either intervention group (n=71) or the comparison group (n=71)."

	Participant selection was based on a small convenience sample. No multivariable analysis to control for baseline covariates.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	No. No multivariable analysis conducted. Paired t-tests used to test within group changes. Differences in outcomes between two groups were tested with ANCOVA.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	No. No multivariable analysis conducted.
Other Was the study free from other sources of bias?	No. Primary outcomes were self-reported. Unclear whether assessors or analysis were blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	No. Small sample size. No sample size calculation provided.

Dunker 2018

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis able to control for selection bias?	Yes. “Randomization was performed at the school level to prevent contamination across students between the intervention and observation arms. We used an

	allocation ratio of 1:1. School names were assigned to paper slips and then randomly selected by the school principals to assign each school to the intervention or control groups. The randomization was not performed with replacement but was blocked, ultimately ensuring an equal sample size between both groups." Convenience sample was used to select individuals within schools. ""The primary researcher advertised the project during school hours to all seventh and eighth-grade students. During the recruitment process, only girls were asked to participate in a research study to evaluate the impact of the following aspects in preventing weight-related issues: body satisfaction, eating habits, and physical activity. After the randomization process, schools in the intervention arm were informed about the NMP activities" p4 Unclear whether allocation was concealed. Randomization occurred after recruitment.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	Unclear. Multivariable analysis conducted (GEE). Comparable # of losses to follow-up across groups. Significant differences between groups at baseline for SES and weight.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. Participants were volunteers therefore aware they were in a study.
Spillovers and crossovers Was the study adequately protected against performance bias?	Yes. "Randomization was performed at the school level to prevent contamination across students between the intervention and observation arms."
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	Yes. Multivariable analysis conducted. ITT analysis.
Other	Yes.

Was the study free from other sources of bias?	Primary outcome objectively measured. Analysis was blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Unclear. Analysis accounted for clustering, but sample size was calculated based on individuals (not clusters).

Jeihooni 2019

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis able to control for selection bias?	No. Allocation mechanism inadequately described. "4 schools out of 22 female high schools with similar economic and social conditions were selected randomly in cluster sampling and subjects were randomly divided into two groups of experimental and control (100 subjects for experimental and 100 subjects for control groups) ... Finally, the 100 samples were allocated in each group." Unclear whether allocation was concealed. Unclear whether recruitment happened before randomization. No multivariable analysis conducted.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	No. No multivariable analysis conducted. No losses to follow-up. No significant differences between groups at baseline.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.

Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	No. No multivariable analysis conducted.
Other Was the study free from other sources of bias?	Unclear. Unclear whether assessors/analysis were blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Unclear. Sample size calculation not adequately described.

Jeihooni 2021

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	No. Mechanism of assignment inadequately described. "Out of twenty-four girls' public high schools, four schools were randomly selected (two as the experiential group and two as the controlled group), with forty students from each school. Samples were to be volunteers and study at one of the public high schools." Unclear whether allocation was concealed. No mention of recruitment before allocation. No multivariable analysis conducted.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	No. No multivariable analysis conducted. No losses to follow-up. No significant differences between groups at baseline. "There wasn't any significant difference between the two groups based on the independent t-test (p = 0.204). Regarding the education level (p = 0.144),

	household monthly income (p = 0.202), father's education (p = 0.198), mother's education (p = 0.186), mother's occupation (0.331), fathers' occupation (p = 0.221), there was no statistically significant difference between the two groups (Table 1). The results also showed that there was no significant difference between the two groups in terms of knowledge, attitude, self-efficacy, reinforcing factors, enabling factors, and nutritional behaviors preventing iron deficiency anemia before the intervention…"
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. Participants were volunteers therefore aware they were in a study.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	No. No multivariable analysis conducted. No mention of blinding assessors/analysis.
Other Was the study free from other sources of bias?	Unclear. Unclear whether assessors/analysis were blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Yes. Sample size calculation appropriate.

Kapadia-Kundu 2014

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis, able to control for selection bias?	Yes. "A cluster RCT was conducted from January 2010 to October 2011 with adolescent girls (11e14 years of age) in 30 rural schools in Hardoi district. The trial is a

	two-level, nested RCT with the unit of randomization being the block. Hardoi has 19 blocks with about 180,000 to 240,000 population per block. The district's main town, Hardoi city is located in the center of the district.Blocks were stratified based on distance from Hardoi city to ensure equitable inclusion of schools from the remotest blocks… After stratification of blocks, two blocks were randomly selected from each of the strata resulting in three pairs of blocks… Random assignment of blocks to intervention or control was done after the baseline survey. A list of girls' schools was prepared for each block. Five schools were then randomly selected from each block, resulting in a total of 30 schools. A list of girls from grades 7 and 8 was prepared and 40 girls were randomly selected from each school. If the school had less than 40 girls in grades 7 and 8, then girls from grade 6 were randomly selected." Recruitment undertaken before randomization.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	Unclear. Study uses cross-sectional (vs panel) data. Baseline characteristics between groups appear similar (Table 2) but no statistical tests presented to compare samples at baseline and endline within and between groups.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Yes. "A cluster RCT was opted for instead of an individually-based RCT to avoid contamination between intervention and control groups in a school."
Selective outcome reporting Was the study free from outcome reporting bias?	Unclear. Outcomes are not described in the Methods section.
Selective analysis reporting Was the study free from analysis reporting bias?	Yes. Credible analysis methods used. "Data were analyzed at the individual and cluster levels. Individual level analysis includes adjusted chi square analysis looking at a difference in proportions. The chi square

	for the individual level analysis was adjusted for clustering using the Rao Scott statistic (Reed, 2004). The analysis looked at the difference in proportion for the four groups. In addition, cluster level analysis was done using a two-sample t-test for comparisons of means between baseline and end line for both the intervention and control groups."
Other Was the study free from other sources of bias?	Unclear. Outcome data were collected by interview and may be subject to bias.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Yes. Adequate sample size and clustering accounted for in analysis.

Leme 2018

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis able to control for selection bias?	Yes. "The schools were pair matched based on geographic location, size, and demographics and randomized within pairs by an individual not involved in the research project. For instance, the numbers one or two were written on individual small papers then folded, and added to a plastic bag. Each number represented a school (e.g., number 1 was school A). Schools remained in their allocated group for the duration of the study." Allocation concealment unclear. Recruitment was undertaken before randomization.
Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	Unclear. Authors used mixed model repeated measures ANCOVA that controlled for baseline values. There were statistical differences between groups at baseline. Concerns about attrition. "At the 6-month post-intervention assessments, 89 (62.7%) and 55 (49.6%)

	girls were retained in the intervention and control groups, respectively (Fig. 1) and no significant differences were found between retained and dropped girls in relation to socio-demographic variables."
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. Outcomes in protocol (Leme 2015) match those reported.
Selective analysis reporting Was the study free from analysis reporting bias?	Yes. Credible methods used. ITT analysis conducted.
Other Was the study free from other sources of bias?	Yes. Primary outcomes objectively measured. Assessors were blinded. Authors note that they did not correct for substantial number of tests conducted.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	No. Authors report that the sample size was underpowered to test effects.

Sabet-Sarvestani 2009

Criteria	Assessment
Mechanism of assignment Was the allocation mechanism, or method of analysis able to control for selection bias?	No. Mechanism of assignment inadequately described. "The participants were randomly selected and assigned to two groups." Multivariable analysis not conducted.

Group equivalence Was the method of analysis executed to ensure comparability of groups throughout the study to prevent confounding?	No. Multivariable analysis not conducted. Authors used two-sample t-tests to examine differences between the control and experimental groups, and sequential analysis was used to evaluate the effect of the program over 6 months. 20% dropout rate reported but no further assessment conducted.
Hawthorne and John Henry effects Was the process of being observed causing motivation bias?	Unclear. It is unclear whether participants were aware they were in a trial and if this affected their actions.
Spillovers and crossovers Was the study adequately protected against performance bias?	Unclear. Authors do not address subject.
Selective outcome reporting Was the study free from outcome reporting bias?	Yes. All outcomes reported in the methods section match the results section. No protocol available.
Selective analysis reporting Was the study free from analysis reporting bias?	No. No multivariable analysis conducted.
Other Was the study free from other sources of bias?	Unclear. Unclear whether assessors were blinded.
Confidence intervals Was the study conducted with an appropriately powered sample size and the analysis carried out at the correct unity of treatment assignment?	Yes. Sample size calculation provided. The sample size calculation for this study was based on previously reported intervention changes in weight and body mass index (BMI) in children. These suggested that at least 14 in each group would allow detection of statistically significant differences with an effect size of 0.80.

Qualitative studies



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CASP Checklist: 10 questions to help you make sense of a **Qualitative** research

How to use this appraisal tool: Three broad issues need to be considered when appraising a qualitative study:

- Are the results of the study valid? (Section A)
- What are the results? (Section B)
- Will the results help locally? (Section C)

The 10 questions on the following pages are designed to help you think about these issues systematically. The first two questions are screening questions and can be answered quickly. If the answer to both is "yes", it is worth proceeding with the remaining questions. There is some degree of overlap between the questions, you are asked to record a "yes", "no" or "can't tell" to most of the questions. A number of italicised prompts are given after each question. These are designed to remind you why the question is important. Record your reasons for your answers in the spaces provided.

About: These checklists were designed to be used as educational pedagogic tools, as part of a workshop setting, therefore we do not suggest a scoring system. The core CASP checklists (randomised controlled trial & systematic review) were based on JAMA 'Users' guides to the medical literature 1994 (adapted from Guyatt GH, Sackett DL, and Cook DJ), and piloted with health care practitioners.

For each new checklist, a group of experts were assembled to develop and pilot the checklist and the workshop format with which it would be used. Over the years overall adjustments have been made to the format, but a recent survey of checklist users reiterated that the basic format continues to be useful and appropriate.

Referencing: we recommend using the Harvard style citation, i.e.: *Critical Appraisal Skills Programme (2018). CASP (insert name of checklist i.e. Qualitative) Checklist. [online] Available at: URL. Accessed: Date Accessed.*

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Critical Appraisal Skills Programme

Paper for appraisal and reference: Dunker et al. 2018. https://doi.org/10.1590/0103-1104201

Section A: Are the results valid?

1. Was there a clear statement of the aims of the research?

Yes ☑ Can't Tell ☐ No ☐

HINT: Consider
- what was the goal of the research
- why it was thought important
- its relevance

Comments: " The objective of this report was to reflect on the adaptation, on the difficulties and on the potentialities of implementing the joint prevention program for obesity and eating disorders New Moves for girls from public schools in São Paulo (SP)."

2. Is a qualitative methodology appropriate?

Yes ☑ Can't Tell ☐ No ☐

HINT: Consider
- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal

Comments: The study aim was to share the perspective of the researchers on implementation challenges and lessons learnt for a randomized controlled trial using a case study approach.

Is it worth continuing?

3. Was the research design appropriate to address the aims of the research?

Yes ☐ Can't Tell ☑ No ☐

HINT: Consider
- if the researcher has justified the research design (e.g. have they discussed how they decided which method to use)

Comments: The methods are not described.

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4. Was the recruitment strategy appropriate to the aims of the research?

Yes	
Can't Tell	✓
No	

HINT: Consider
- If the researcher has explained how the participants were selected
- If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study
- If there are any discussions around recruitment (e.g. why some people chose not to take part)

Comments: The report is a reflection by the researchers (authors). It is not clear whether others involved in the trial's implementation were consulted.

5. Was the data collected in a way that addressed the research issue?

Yes	
Can't Tell	✓
No	

HINT: Consider
- If the setting for the data collection was justified
- If it is clear how data were collected (e.g. focus group, semi-structured interview etc.)
- If the researcher has justified the methods chosen
- If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide)
- If methods were modified during the study. If so, has the researcher explained how and why
- If the form of data is clear (e.g. tape recordings, video material, notes etc.)
- If the researcher has discussed saturation of data

Comments: The report does not describe how data were collected or analyzed.

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6. Has the relationship between researcher and participants been adequately considered?

Yes	
Can't Tell	✓
No	

HINT: Consider
- If the researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

Comments: It is unclear whether anyone other than the study authors provided data for the study.

Section B: What are the results?

7. Have ethical issues been taken into consideration?

Yes	
Can't Tell	✓
No	

HINT: Consider
- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

Comments: It is unclear whether anyone other than the study authors provided data, and therefore, unclear whether ethics was required.

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8. Was the data analysis sufficiently rigorous?

Yes	
Can't Tell	✓
No	

HINT: Consider
- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

Comments: The analysis approach is not described.

9. Is there a clear statement of findings?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

Comments: " The NMB has the potential to be replicated and used as a reference for new intervention models in the country, requiring adaptations in its contents, with a reduction in the amount of information of the manual, as well as the reduction of activities proposed in each session, specifically those related to social support and food, so that they are better understood by populations with learning difficulties and arouse interest in the topics addressed. For being considered a international reference, with many positive results, can be used as a model of differentiated behavioral strategy, and can be proposed in full-time schools as an optional subject aimed at girls."

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Section C: Will the results help locally?

10. How valuable is the research?	HINT: Consider • If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature • If they identify new areas where research is necessary • If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used

Comments:	The research provides valuable information on the challenges of culturally adapting obesity and eating disorder programmes designed in high-income countries to low- and middle-income country contexts.

Appendix D: GRADE assessments

Summary of findings:

Empowerment-based nutrition interventions compared to usual care/control for improving adolescent girls' nutritional status in LMICs (RCTs)

Patient or population: improving adolescent girls' nutritional status in LMICs (RCTs)

Setting: LMIC

Intervention: empowerment-based nutrition interventions

Comparison: usual care/control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with usual care/control	**Risk with empowerment-based nutrition interventions**				
Body Mass Index (BMI) follow-up: range 6.5 months to 12 months	The mean body Mass Index was **23.1** kg/m2	MD **0.01 kg/m2 lower** (0.77 lower to 0.76 higher)	-	695 (3 RCTs)	⨁⨁◯◯ Low[a]	Empowerment-based nutrition interventions may result in little to no difference in Body Mass Index.
Waist circumference (WC) follow-up: range 7.5 months to 12 months	The mean waist circumference was **79.7** cm	MD **0.02 cm lower** (2.44 lower to 2.4 higher)	-	425 (2 RCTs)	⨁◯◯◯ Very low[a,b]	Empowerment-based nutrition interventions may reduce/have little to no effect on Waist Circumference, but the evidence is very uncertain.
Total energy intake follow-up: range 7.5 months to 12 months	-	SMD **0.15 SD lower** (0.52 lower to 0.22 higher)	-	425 (2 RCTs)	⨁◯◯◯ Very low[a,b]	Empowerment-based nutrition interventions may reduce/have little to no effect on Total Energy Intake, but the evidence is very uncertain.
Self-Efficacy follow-up: range 7.5 months to 12 months	-	SMD **1.04 SD higher** (0.81 higher to 1.26 higher)	-	338 (2 RCTs)	⨁◯◯◯ Very low[a,b,c]	Empowerment-based nutrition interventions may increase/have little to no effect on Self-Efficacy but the evidence is very uncertain.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

Summary of findings:

Empowerment-based nutrition interventions compared to usual care/control for improving adolescent girls' nutritional status in LMICs (RCTs)

Patient or population: improving adolescent girls' nutritional status in LMICs (RCTs)

Setting: LMIC

Intervention: empowerment-based nutrition interventions

Comparison: usual care/control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with usual care/control	**Risk with empowerment-based nutrition interventions**				

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. Studies only include middle-income countries; interventions only target overnutrition.

b. Small sample size.

c. One study at high risk of selection bias; outcome is self-reported.

Summary of findings:

Empowerment-based nutrition interventions compared to usual care/control for improving adolescent girls' nutritional status in LMICs (NRS)

Patient or population: improving adolescent girls' nutritional status in LMICs (NRS)

Setting: LMIC

Intervention: empowerment-based nutrition interventions

Comparison: usual care/control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with usual care/control	**Risk with empowerment-based nutrition interventions**				
Body Mass Index (BMI) follow-up: mean 4 months	The mean body Mass Index was **30.4** kg/m2	MD **1.14 kg/m2 lower** (1.62 lower to 0.66 lower)	-	260 (2 observational studies)	⨁◯◯◯ Very low[a,b,c]	Empowerment-based nutrition interventions may reduce/have little to no effect on Body Mass Index, but the evidence is very uncertain.
Anemia follow-up: mean 5.5 months	85 per 100	**32 per 100** (20 to 54)	**RR 0.38** (0.23 to 0.63)	68 (1 observational study)	⨁◯◯◯ Very low[a,c,d]	Empowerment-based nutrition interventions may reduce/have little to no effect on Anemia, but the evidence is very uncertain.
Total Energy Intake	-	SMD **0.28 SD higher** (0.38 lower to 0.94 higher)	-	310 (3 observational studies)	⨁◯◯◯ Very low[a,c,e]	Empowerment-based nutrition interventions may increase/have little to no effect on Total Energy Intake, but the evidence is very uncertain.
Haemoglobin (Hb) follow-up: range 4 months to 5.5 months	The mean haemoglobin was **0**	not pooled	-	228 (2 observational studies)	⨁◯◯◯ Very low[a,c,f]	Empowerment-based nutrition interventions may increase/have little to no effect on Haemoglobin, but the evidence is very uncertain. Study 1: MD = 0.95 (95%CI 0.65, 1.25); Study 2: MD = 0.34 (95%CI 0.08, 0.60).
Self-Efficacy follow-up: range 3 months to 8 months	The mean self-Efficacy was **0**	not pooled	-	602 (4 observational studies)	⨁◯◯◯ Very low[a,b,c,g,h]	Empowerment-based nutrition interventions may increase/have little to no effect on Self-Efficacy but the evidence is very uncertain. Study 1: SMD = 0.47 (95%CI 0.08, 0.87). Study 2: SMD = 0.41 (95%CI 0.08, 0.74). Study 3: SMD = 6.31 (95%CI 5.63, 7.00). Study 4: SMD = 5.61 (95%CI 4.92, 6.31).

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **MD:** mean difference; **RR:** risk ratio; **SMD:** standardised mean difference

Summary of findings:

Empowerment-based nutrition interventions compared to usual care/control for improving adolescent girls' nutritional status in LMICs (NRS)

Patient or population: improving adolescent girls' nutritional status in LMICs (NRS)

Setting: LMIC

Intervention: empowerment-based nutrition interventions

Comparison: usual care/control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with usual care/control	**Risk with empowerment-based nutrition interventions**				

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. Non-randomized design subject to selection bias and confounding.

b. Studies only include middle-income countries; only target overnutrition.

c. Small sample size.

d. Study population: adolescent girls with iron deficiency anemia

e. Substantial heterogeneity I2 = 88%

f. Substantial heterogeneity I2 = 89%

g. Substantial heterogeneity I2 = 99%

h. Included studies all conducted in Iran.

RCTs

Outcome: BMI		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	3 RCTs	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Not serious	
Other	None	

Outcome: Waist circumference		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	2 RCTs	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Total energy intake		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	2 RCTs	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size.
Other	None	

Outcome: 3 meals + snack		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Food variety index		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Sprouted legumes		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Vitamin C foods		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: IFA consumption		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	

Other	None	

Outcome: DOTS for IFA		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Annual health check		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Deworming tablet		**Certainty: Moderate**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Uses cross-sectional data. Selective reporting unclear because outcomes not defined. Blinding of assessors unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Not serious	
Other	None	

Outcome: Fruit & veg intake		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Serious	Significant baseline imbalances. No allocation concealment reported. Blinding not reported.
Inconsistency	Not serious	
Indirectness	Serious	Study population: middle-income, overweight
Imprecision	Serious	Small sample size
Other	None.	

Outcome: Fruit intake		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other		None

Outcome: Veg intake		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other		None

Outcome: Dairy intake		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	2 RCTs	
RoB	Serious	One study with significant baseline imbalances. No allocation concealment reported. Blinding not reported.
Inconsistency	Very serious	I2 = 98%
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other		

Outcome: Fat and oil servings		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	2 RCTs	
RoB	Serious	One study with significant baseline imbalances. No allocation concealment reported. Blinding not reported.
Inconsistency	Very serious	I2 = 94%
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other		

Outcome: Rice servings		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other		

Outcome: Meat servings		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

Outcome: Beans servings		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

Outcome: Sweets servings		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	
RoB	Not serious	
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

Outcome: Junk food servings		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	1 RCT	

RoB	Serious	Significant baseline imbalances. No allocation concealment reported. Blinding not reported. Outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

Outcome: Self-efficacy		**Certainty: Low**
	Assessment	Explanation
No. of studies and design	2 RCTs	
RoB	Serious	One RCT has unclear risk of selection bias; outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

NRS

Outcome: BMI		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	2 CBA	
RoB	Very serious	High risk of selection bias & confounding. Blinding unclear. Blinding unclear.
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None	

Outcome: Hb		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	2 CBA	
RoB	Serious	Non-randomized design. Blinding unclear.
Inconsistency	Serious	I2 = 89%
Indirectness	Not serious	
Imprecision	Serious	Small sample size
Other	None	

Outcome: Serum ferritin		**Certainty: Very low**
	Assessment	Explanation

No. of studies and design	2 CBA	
RoB	Serious	High risk of selection bias & confounding. Blinding unclear.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Anemia		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	1 CBA	
RoB	Serious	Risk of selection bias & confounding. Blinding unclear.
Inconsistency	Not serious	
Indirectness	Serious	Study in adolescents with IDA
Imprecision	Serious	Small sample size
Other		

Outcome: Total Energy Intake		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 88%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Total protein		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 78%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome:		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Not serious	

Imprecision	Serious	Small sample size.
Other	None	

Outcome: Dietary iron		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 73%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Folate		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 85%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Vitamin A		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Zinc		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 89%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Folate		**Certainty: Very low**

	Assessment	Explanation
No. of studies and design	3 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Serious	I2 = 85%
Indirectness	Not serious	
Imprecision	Serious	Small sample size.
Other	None	

Outcome: Dairy intake		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	1 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None.	

Outcome: Breakfast consumption		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	1 CBA	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Not serious	
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None.	

Outcome: Self-efficacy		**Certainty: Very low**
	Assessment	Explanation
No. of studies and design	4 CBAs	
RoB	Very serious	Risk of selection bias & confounding. Blinding unclear. Outcome is self-reported.
Inconsistency	Very serious	I2 = 99%
Indirectness	Serious	Only middle-income countries; interventions only target overnutrition.
Imprecision	Serious	Small sample size
Other	None.	

CHAPTER 4: Associations between married adolescent girls' empowerment and their nutritional status in East Africa

Chapter overview

Chapter 4 addresses the second research objective presented in Chapter 1: To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs. The chapter presents a manuscript published in *BMC Public Health* of a structural equation modelling study that used cross-sectional data from five East African countries to model the relationship between dimensions of empowerment and married adolescent girls' nutritional status.

We developed this study to fill an evidence gap on the specific challenges/opportunities for adolescent girls' empowerment in relation to their nutrition because similar studies to date have primarily focused on adult women's empowerment and maternal and child nutrition outcomes. We selected the region of East Africa because it is an understudied region where gender inequalities and malnutrition persist. The empowerment process is context-specific, thus we wanted to focus on understanding the empowerment–nutrition relationship in a specific geographical region that can be used to inform policy and programme design. Finally, we used exploratory structural equation modelling (ESEM) because of its ability to model complex concepts that cannot be directly measured (i.e., there is no "one" objective measure for empowerment as there is for weight, for example) while properly accounting for measurement error. This is the first study of empowerment that uses ESEM.

In Chapter 5 we present the findings of similar models for single adolescent girls in East Africa. We chose to model these two populations separately for two reasons. First, single versus married adolescent girls likely face different challenges or opportunities to their empowerment and nutrition because they are at different life stages. We wanted to understand how these different life stages affect empowerment and nutrition. Second, our dataset provided more empowerment-related measures for married respondents compared to single respondents. This provided us the opportunity to develop a more complex model for married adolescent girls.

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Authors' roles and contributions

AYR conceived the study and wrote the original draft. AYR, WL, GAW, and VW verified the underlying data. AYR, WL, ZAB, MT, CV, EK, GAW, VW contributed to the study methodology. AYR with support from WL conducted the investigation and formal analyses with supervision from GAW and VW. All authors contributed to the review and editing of the article. AYR, GAW, and VW secured funding for the study. All authors had final responsibility for the decision to submit for publication.

Related thesis appendices

Appendix A2: Published manuscripts. The PDF of the published manuscript is presented in Appendix A2.

Appendix A3. Mplus Code. An example of the exploratory structural equation modelling code is provided in Appendix A3.

Appendix A4. Mplus output. An example of the exploratory structural equation modelling output is provided in Appendix A4.

Associations between dimensions of empowerment and nutritional status among married adolescent girls in East Africa: A structural equation modelling study

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Abstract

Background: Empowering adolescent girls is an important component of combating malnutrition in this age group. Because empowerment is multidimensional and context specific, it can be difficult for policymakers and practitioners to target the dimensions of empowerment associated with adolescent girls' nutrition in a particular setting. This study sought to identify the empowerment dimensions significantly associated with married adolescent girls' nutritional status in East Africa; a region where malnutrition and gender inequality stubbornly persist.

Methods: We used cross-sectional Demographic and Health Survey (DHS) data from Ethiopia (2016), Kenya (2014), Tanzania (2015-16) and Uganda (2016) to construct and test theoretically informed structural equation models of the relationship between six dimensions of empowerment and BMI-for-age and haemoglobin levels for married adolescent girls aged 15-19 years.

Results: Our models were found to be a good fit for the data. Married adolescent girls' access to information, measured by their education level and mass media use, was directly and positively associated with their BMI-for-age ($p < 0.05$). Asset ownership, measured by owning a house or land alone or jointly, was directly and positively associated with haemoglobin ($p < 0.05$) and reduced odds of being moderately to severely anemic. Rejecting justifications for intimate partner violence, a measure of respondents' intrinsic agency, was directly and positively associated with the odds of being overweight or obese. Adolescent girls' level of empowerment across all dimensions had a direct relationship with their country of residence and household wealth.

Conclusions: Our findings suggest that investment in girls' access to information through education and mass/social media and their economic empowerment may be important contributors to their overall empowerment and nutritional status. However, caution is needed as greater autonomy may contribute to increased consumption of unhealthy foods that can contribute to overweight and obesity. Strategies to empower married adolescent girls should be tailored to their specific circumstances. There is an urgent need for better data on adolescent empowerment and health, including increased research into age-, sex- and gender-appropriate empowerment measures and longitudinal data to assess causality. The use of statistical models should be complemented by robust qualitative research to further results interpretation.

Keywords

Adolescent girls; Adolescent Nutrition; Adolescent Empowerment; East Africa; Structural Equation Models

Background

Late adolescence, from the ages of 15 to 19 years, is a time of important physiological growth and neurodevelopment for girls that can be undermined by poor nutrition. Bone acquisition continues into late adolescence, with final bone mineral content plateauing in girls at around 18 years.[1] Undernutrition in late adolescence can have negative consequences on brain development while chronic malnutrition increases the risk of adiposity and non-communicable diseases later in life.[1] Adolescent pregnancy has several negative consequences for adolescent girls' health and contributes to an intergenerational cycle of malnutrition.[2]

East Africa is a region where progress on addressing malnutrition among adolescent girls is slow. In the last decide, thinness (BMI-for-age (ZBFA) < -2 standard deviations (SD)) among girls aged 5-19 years in East Africa declined only 0.5% to 4.6%, while the prevalence of overweight and obesity (ZBFA > 1 SD) increased from 5.5% to 17.3% over the same period.[3] Approximately 32% of all women and girls aged 15-49 years in the region are anemic.[3]

Sex- and gender-related disparities in nutrition are a consequence of physiological and sociocultural factors. Iron-deficiency anemia affects both sexes, but adolescent girls carry the greatest burden due to the additional iron requirements that come with the onset of menarche. Boys acquire more lean body mass during adolescence while girls accrue more fat body mass, contributing to higher rates of thinness in boys and overweight and obesity in girls.[1] Early and child marriage contributes to adolescent pregnancy which accounts for over 10% of global total births annually.[4] The competition for nutrients between the still growing mother and the fetus restricts maternal growth and increases the risk of preterm delivery, low birthweight, and small-for-gestational age among neonates.[5] Son preference in families results in many girls eating last, least, and of lesser quality compared to boys and men in the household.[6] It also de-prioritizes their timely access to healthcare needed to prevent disease and unwanted pregnancy.

The drivers of malnutrition among adolescents are multifactorial. Individual behaviours such as food choice, dietary intake and physical activity are influenced by the food environment which is shaped by household and community dietary and activity patterns, economic development, urbanization and food and agriculture systems.[7] Gender inequality and restrictive gender norms play an important role in shaping these socio-ecological systems and disproportionately contribute to women and girls' poor health.[7,8] Rigid gender norms are absorbed as early as age 10, coinciding with a shift in boys and girls' roles in the family and community on gendered lines.[9] For girls, this often means a decline in their agency and autonomy relative to boys, yet agency, or their ability to define and achieve goals, is critical

to adolescent well-being.[10] The empowerment of adolescent girls is an important component of combating malnutrition in this age group.[11–13] Empowering married adolescent girls may require special attention compared to adult women. This group can face additional challenges to their agency and autonomy due to their relatively young age and lower status in the household. Younger age at marriage is associated with decreased bargaining power in the household.[14] Large age gaps between child brides and their husbands further disempower adolescent girls in the household hierarchy.[15] Married adolescents are more likely to become pregnant and prematurely leave school, stunting their learning and limiting their economic prospects.[16] Child marriage itself is a disempowering action and a human rights violation as girls often have little say in the decision of when and who to marry.[17]

Empowerment is a complex construct that is multidimensional and context specific. As such, it can be difficult for policy makers and practitioners to identify and target the dimensions of empowerment that may positively influence adolescent girls' nutrition in a particular setting. A recent systematic review of women's empowerment measures in developing countries found the most common dimensions measured were household decision making, financial and economic decision making, freedom of movement, self-esteem, and sexual and reproductive decision making.[18] Further, there is evidence that different dimensions of women's empowerment influence maternal and child nutrition differently.[19–22] We hypothesized that a similar phenomenon exists for married girls in late adolescence, but there may be differences as to which empowerment dimensions are significant given this population's particular nutritional and empowerment-related challenges. Compared to adult women, the relationship between married adolescent girls' empowerment and their nutritional status is understudied. As such, the objective of this study was to model the relationship between dimensions of married adolescent girls' empowerment and their nutritional status using cross-sectional Demographic and Health Survey data from four East African countries (Ethiopia, Kenya, Tanzania, and Uganda).

Methods

Conceptualizing empowerment

Empowerment refers to "the process by which those who have been denied the ability to make strategic life choices acquire such an ability."[23] It involves a progression from a position of lacking choice, to once in which choice is exercised. Most importantly, it reflects *agency*, or the "ability to define one's goals and act upon them," in important life areas.[23] Decisions regarding strategic life choices have long term consequences for a person's life course and well-being, such as those regarding their education, reproductive health, and economic prospects. Agency over strategic life choices contributes to the realization and protection of individuals' human rights.

Empowerment is a complex and multidimensional construct. People can be empowered or disempowered in different area of their lives, which we term, *dimensions*. For example, a married adolescent girl may have the ability to choose what food is cooked daily, but she may not make decisions regarding contraceptive use. The ability to make strategic life choices across different dimensions reflects a person's *capabilities*. Capabilities are ways of 'doing or being,' or what people are actually able to be or do in different life areas that are important to them.[24,25]

A person's ability to access and control resources is crucial to the empowerment process. Kabeer identifies resources as necessary preconditions to the exercise of agency.[23] Resources are defined broadly to encompass not only economic or financial resources, such as earning an income or owning assets, but also human and social capital, time, and information. The more disempowered an individual, the greater likelihood that they have limited resources at their disposal. An individual's access to resources is shaped by their surrounding political, economic, legal, and socio-cultural environment. Alsop and Heinsohn (2005) define this concept as a person's *opportunity structure*, or the formal and informal institutions including laws, regulatory frameworks, and norms that define people's behaviours. They state that "[t]he presence and operation of the formal and informal laws, regulations, norms, and customs determine whether individuals and groups have access to assets, and whether these people can use the assets to achieve their desired outcomes."[26]

Our conceptual model (Figure 1) brings together these components of empowerment to describe a process whereby agency, resources, and opportunity structure work together to create individual capabilities. These capabilities across different dimensions of empowerment are proposed to contribute to the achievement of an individual's goals. Specifically, our model theorizes that adolescent girls' capabilities across six empowerment dimensions have a direct influence on their nutritional status (Figure 1). The dimensions are: (1) the ability to access information, (2) the ability to access healthcare, (3) the ability to make household decisions, (4) the ability to reject intimate partner violence, (4) the ability to own assets, and (6) the ability to exert social independence. The empowerment dimensions are measured (imperfectly) as latent constructs using observed indicators from the DHS. We reviewed existing studies (see Additional File 1) that modelled the nutrition-empowerment relationship using DHS data to identify indicators and empowerment dimensions to include in our model. We sought to identify indicators that measured not only the ability to make decisions (a direct measure of agency), but also measures of adolescent girls' access to resources and the existence of a supportive opportunity structure that would promote adolescent girls' agency and empowerment. Indicators selected for inclusion had to be (1) available across datasets with the percentage of missing data close to zero, (2) previously used as a

measure of empowerment, (3) have sufficient variation to have adequate explanatory power, (4) be theoretically justified, and (5) contain no indicator correlations greater than 0.95.[27,28] Details on indicator coding and scales are available in Additional File 1.

Dimension 1: Access to information

Access to information is necessary for adolescent girls to make informed decisions about their health and nutrition. We identified four relevant DHS indicators that we hypothesized would measure this construct. The first indicator was adolescent girls' level of completed education (measured in years). Education level is a strong predictor of health and nutrition among women and girls.[29] The remaining indicators measured respondents' use of mass media. The DHS asks respondents about the frequency in which they (1) watched television, (2) read the newspaper or magazine, and (3) listened to the radio. The use of mass media in behaviour change interventions has been shown to positively influence health-related knowledge and attitudes among adolescents and has the potential to positively shape gender norms alongside social media and technology.[30,31]

Dimension 2: Access to healthcare

Adolescent girls can face various barriers to healthcare, many of which are linked to gender norms and inequality. Limited access to healthcare contributes to their increased risk of illness, disease, and unwanted pregnancy - all important contributors to malnutrition in this population. The DHS includes four variables to assess respondents' ability to access healthcare by asking them to indicate whether the following barriers to healthcare are "a big problem/not a big problem": (1) getting permission to go, (2) not wanting to go alone, (3) getting money for treatment, and (4) distance to the health facility.

Dimension 3: Role in household decision-making

Decision-making power is frequently used as a measure of agency and autonomy. The DHS includes four indicators to assess married respondents' level of participation in household decision-making (either not at all, alone, or jointly with their partner/other household member) in the following situations: (1) when the respondent wants to seek healthcare for themselves, (2) when they want to visit family or relatives, (3) when large household purchases are made, and (4) when decisions about their husband's income are made.

Dimension 4: Rejecting IPV

Adolescent girls' views on intimate partner violence reflect the degree to which they have internalized harmful gender norms. Other studies have used these indicators to measure women's intrinsic

agency.[32–34] The DHS asks respondents whether they agree (yes/no) that a husband is justified in beating his wife under the following scenarios: (1) when she neglects the children, (2) when she burns food, (3) when she refuses sex with her husband, (4) when she goes out without telling her husband, and (5) when she argues with her husband.

Dimension 5: Asset ownership

Access to these various assets was hypothesized to capture respondents' financial autonomy and their ability to access and control financial resources. Three indicators were included in this dimension: (1) whether the respondent owns a house either alone or jointly, (2) whether the respondent owns land either alone or jointly and (2) whether the respondent earns a cash income.

Dimension 6: Social independence

The final dimension examined respondents' ability to counter negative social norms that disempower women and girls, such as child/early/forced marriage and adolescent pregnancy. It included (1) respondent's age at first cohabitation (a higher age was interpreted as greater empowerment) [35], (2) respondent's age at first sex (early sexual activity is often due to a lack of choice and further disempowers girls' when adolescent pregnancy leads to school dropouts) [36], (3) respondent's age difference with her partner (smaller gap = greater empowerment), and (4) her education level difference with her partner (smaller gap = greater empowerment).

Data and study sample

The study population was adolescent girls in late adolescence (15-19 years) who (1) were surveyed as part of the most recent DHS VII surveys conducted in Ethiopia, Kenya, Tanzania, and Uganda (2) were selected for anthropometric and anemia testing and (3) reported being currently partnered (married) at the time of the survey.

The DHS is a nationally representative cross-sectional survey of women of reproductive age (15-49 years) and men aged 15-49 years, 15-54 years, or 15-59 years. The survey sample is based on a stratified two-stage cluster design that is typically representative at the national level, at the residence level (urban/rural), and the regional level (e.g., states). The DHS uses standardized questionnaires and has large sample sizes (usually between 5,000 and 30,000 households). The surveys are conducted in low- and middle-income countries with support from the U.S. government approximately every five years to allow for comparisons across countries and time.

The DHS is one of the only data sources with cross-country comparable quantitative data on older adolescent girls' (15-19 years) nutrition and empowerment. While the module is not specifically designed for adolescent girls, it can still provide insights into their empowerment and nutrition. The DHS women's status module assesses female respondents' ability to participate in household decision-making (collected for married respondents only), their attitudes toward gender roles, their employment, and their ownership of a house or land.

Outcome measures

We assessed the direct association of dimensions of empowerment on adolescent girls' BMI-for-age (z-score) and haemoglobin levels (Hb) (g/dl). A separate model was tested for each nutrition outcome. Z-scores were calculated using the 2007 WHO growth standards for age and sex.[37] Haemoglobin values were adjusted for altitude and smoking status.[38] Furthermore, we dichotomized respondents' BMI-for-age and haemoglobin outcomes to construct and test models for the following: (1) thinness (ZBFA < -2 SD), (2) anemia (Hb < 12.0g/dl for non-pregnant respondents and Hb <11.0g/dl for pregnant respondents), (3) moderate to severe anemia (Hb < 11.0g/dl for non-pregnant respondents and Hb <10.0g/dl for pregnant respondents), and (4) overweight/obesity (ZBFA > 1 SD).

Covariates

Independent variables for adolescent girls' country of residence, household wealth, breastfeeding status and pregnancy status were included in the model to control for their effects on nutritional status.[39–42] We selected covariates based on a review of similar studies, the content and methodological expertise of the author team, and variable availability in the DHS. The BMI-for-age model controlled for the current breastfeeding status of respondents (yes, no), household wealth (measured as a continuous composite measure of a household's cumulative wealth as part of the DHS), and country of residence. Pregnant respondents were omitted from the BMI-for-age model. We included country of residence as a proxy measure of engrained rules, norms, and practices that shape choice for adolescent girls.[23] Effect coding was used to create dummy variables for country of residence whereby ones, zeros, and negative ones were used to assign group (country) membership.[43] Indicator values represented the deviation of the country value from the unweighted grand mean (UGM) of the outcome variable. The Hb model included the same covariates and controlled for current pregnancy status (yes, no).

Model development and testing

We employed exploratory structural equation modelling (ESEM) with covariates to construct and test our model. Structural equation modelling (SEM) is a group of statistical procedures used for causal inference

that tests hypotheses regarding the linear relations among observed variables and latent constructs (or factors).[27] SEM uses a combination of factor analysis and multiple regression analysis and is appropriate for research questions that involve complex, multifaceted constructs measured with error, and to specify systems of relationships with direct and indirect effects.[44] Because empowerment is multi-dimensional and cannot be directly measured, SEM offers a viable alternative to multiple regression because it can appropriately accommodate multiple indicators measuring a latent construct with measurement error. The basic datum analysed in SEM is covariance, which represents the strength of the linear association between two variables. The observed variables can be continuous, censored, binary, ordered categorical (ordinal), and combinations thereof.[45] The goals of SEM are to understand the patterns of covariance among a set of observed variables and to explain as much of their variance as possible with the model. Exploratory structural equation modelling (ESEM) is a less restrictive SEM approach that allows observed variables to (minimally) cross-load onto more than one factor instead of restricting factor loadings to zero on all other factors it is not designed to measure. Such a restriction has been shown to be unrealistic in real world settings and contribute to the inflation of factor correlations and biased estimates.[46]

We built the model in a stepwise manner, beginning with an exploratory factor analysis (EFA) of the 24 empowerment indicators (see left-hand side of Figure 1) using Mplus Version 8.[45] The Mean- and Variance-Adjusted Weighted Least Squares (WLSMV) estimator was used, and an oblique (geomin rotation) was applied. A series of 1 to 10 factor models were run. Complex survey design was incorporated using TYPE=COMPLEX in the Analysis command along with variables for stratification, weighting, and clustering, as per the DHS survey design for each country. Empowerment indicators were retained if their primary factor loading was above 0.40, below 0.30 for alternative factors, and theoretically justified.[47] Model fit was assessed using recommended model fit indices and corresponding cut-offs.[44] The number of extracted factors was determined by model fit values, scree plot inspection and Eigenvalue > 1, factor interpretability, and parsimony. Factor quality was assessed by examining the number of indicators that loaded on each factor and the correlation between the estimated factor score and the factor.[44]

Once a stable EFA structure with good fit was obtained, a nutrition outcome was added to the model to assess the direct effect of each factor (empowerment dimension) on the outcome of interest using regression analysis (right-hand side of Figure 1). Covariates were added in the following step and model stability and fit were re-assessed. As a final step, modification indices were checked to identify missing paths that were theoretically justified, and improved model fit.[44] Indicators that contributed to a not positive definite residual covariance matrix were investigated and, where appropriate, removed from the

model. The model was then re-run. Separate models were run for BMI-for-age, Hb, thinness (ZBFA < -2 standard deviations from the reference population), overweight and obesity (ZBFA > 1 SD), anemia (Hb < 12.0g/dl for non-pregnant respondents and Hb <11.0g/dl for pregnant respondents), and moderate to severe anemia (Hb < 11.0g/dl for non-pregnant respondents and Hb <10.0g/dl for pregnant respondents).. Statistical significance was determined at the $\alpha < 0.05$ level. The unit of analysis was the individual respondent.

Results

Study population characteristics

The total sample size was 1,927 married adolescent girls (Table 1). The mean age of respondents was 17.9 years (SD = 1.1). Most were from the two poorest socio-economic quintiles (57.6%) and lived in rural settings (80.2%). Education levels varied by country, with Ethiopia having the lowest mean level of completed education (3.8 years, SD = 3.5), and Kenya the highest (6.5 years, SD = 3.6). Almost 22% of respondents were pregnant and 41.2% were breastfeeding at the time of the surveys. The mean BMI of non-pregnant respondents was 20.8 kg/m^2. The prevalence of thinness and overweight (including obesity) among non-pregnant respondents was 3.5% and 7.0%, respectively. Almost 44% of respondents with available data were anemic.

Fifty-five percent of respondents reported listening to the radio while only 28.5% watched TV and 18.9% read the newspaper (Table 2). The highest reported barriers to healthcare were money (41.6%) and distance (44.4%). Respondent's average age at first cohabitation and first sex were 16.1 years and 15.5 years, respectively. Just over 28% earned some cash income. Over 39% owned a house and 32.9% owned land, either alone or jointly. Respondents had the greatest role in household decision-making regarding their own healthcare (67.6%) and the lowest influence on decisions regarding large household purchases (52.3%). Most respondents rejected the view that husbands were justified in beating their wives if they burn food (72.9%), but a majority (51.6%) agreed that violence is justified if a wife neglects the children.

Model results

The final model included six empowerment dimensions measured by 21 observed indicators (Table 2) with good model fit (RMSEA = 0.023, CFI = 0.987, TLI = 0.972, SRMR = 0.024). The original six dimensions were retained in the final model; however, three indicators were eliminated because they did not significantly contribute to any dimension: Earns a Cash Income, Age Difference with Partner, Education Difference with Partner.

The final ESEM models for BMI-for-age and haemoglobin are presented in figures 2 and 3. The final models included the addition of paths representing the direct influence of household wealth and country of residence on each empowerment dimension based on a review of modification indices and a consideration of their theoretical justification. Model fit results are presented in Additional File 1. Standardized path coefficients for continuous outcomes and adjusted odds ratios (aOR) for binary outcomes with 95% confidence intervals are reported in this section. Unstandardized results are reported in Additional File 1.

Haemoglobin

After controlling for household wealth, country of residence, pregnancy, and breastfeeding, one empowerment dimension, asset ownership, had a direct positive association with haemoglobin levels among respondents (0.148, (0.061, 0.235)) (Table 3 and Figure 2). Expressed in original units, each one unit increase in asset ownership was associated with a 0.262 (0.108, 0.415) increase in haemoglobin (Additional File 1). No other empowerment dimensions were significantly associated with haemoglobin.

Anemia

Asset ownership was significantly associated with reduced odds of being moderately to severely anemic (aOR = 0.817 (0.716, 0.933)) but the relationship was non-significant ($p > 0.05$) between all empowerment dimensions and anemia when mild cases were included in the model. No other empowerment dimensions were significantly associated with anemia.

BMI-for-age

The final BMI-for-age model included only four empowerment dimensions: access to information, access to healthcare, role in household decision-making, and rejection of IPV. The remaining empowerment domains – social independence and asset ownership – were removed from the model because they produced negative residual variances. Consequently, access to information was the only empowerment domain directly and positively associated with BMI-for-age (0.188, 95% CI = 0.075, 0.301)) among non-pregnant respondents after controlling for household wealth, breastfeeding status, and country of residence (Table 3 and Figure 3). Expressed in original units, a one unit increase in access to information was associated with a 0.113 increase in respondents' BMI-for-age z-score. The remaining empowerment domains were non-significant.

Overweight and obesity

Rejecting justifications for IPV was directly and positive associated with the odds of being overweight or obese (aOR = 1.168, (1.026, 1.330)) among non-pregnant respondents, but the sample size was small

(only 103 respondents (7%) were overweight or obese). No other empowerment dimensions were significantly associated with being overweight or obese.

Thinness

The relationships between thinness and all empowerment dimensions were non-significant after controlling for country of residence, household wealth, and breastfeeding status in non-pregnant respondents. These results should be interpreted with caution due to the small number of respondents who were thin (n = 52 (3.5%)).

Discussion

The relationship between adolescent girls' empowerment and their nutritional status is understudied. This study found a statistically significant association between specific dimensions of married adolescent girls' empowerment and their nutritional status in East Africa using a theoretically informed model of the empowerment–nutrition relationship. Owning assets (a house or land) either alone or jointly was significantly and positively associated with haemoglobin and lower odds of being moderately to severely anemic. Access to information (measured by girls' level of completed education and their mass media use) was significantly and positively associated with BMI-for-age. Rejection of justifications for IPV was associated with the odds of being overweight or obese. No empowerment dimensions were significantly associated with being thin, however the sample size was small. The empowerment dimensions of access to healthcare, role in household decision-making, and social independence were not significantly associated with any assessed nutrition outcomes.

The positive relationships between asset ownership and access to information with haemoglobin and BMI-for-age, respectively, suggest that access to economic and educational resources play an important role in the empowerment–nutrition relationship. In settings where female empowerment is far from complete, such as East Africa, measures of resource access and control may be just as informative as direct measures of agency and may be critical to understanding the process of empowerment.[23,48] Married adolescent girls who (co-)own a house or land, particularly in places where agriculture is the main source of economy for women, may have greater access to resources in general that can translate into access to a good diet and healthcare. Higher education and mass media use may increase adolescent girls' exposure to nutrition- and diet-related information and indirectly affect their nutritional status by reducing adolescent fertility and delaying marriage and childbearing. On the other hand, peer influence, the changing food environment, and mass/social media can promote unhealthy nutrition-related behaviours, such as increased consumption of ultra-processed foods, as well as unhealthy conceptualizations of body image.[13,49] Rejection of justifications of IPV, a measure of girls' intrinsic

agency, was associated with increased odds of being overweight or obese in our study population. A possible explanation is that girls with higher levels of intrinsic agency have greater freedom to exercise choice in their diet and may therefore choose to eat foods that are popular or convenient but may be lacking in nutritional value.

We did not find any significant associations between nutrition outcomes and adolescent girls' social independence. Age at first marriage and first birth (the indicators used to measure social independence) have been previously shown to be associated with nutrition; women who delay marriage and childbearing generally have better maternal and child health and nutrition outcomes. It may be that the absence of important mediating variables along the causal chain from social independence to nutritional status, such as level of education, are needed to help explain the relationship.

Girls' ability to overcome barriers to healthcare access was not significantly associated with their BMI-for-age or haemoglobin. We hypothesized that given our study population was generally healthy (mean Hb = 12.0g/dL, mean BMI = 20.8kg/m^2), they may not regularly seek healthcare, making it difficult to detecting a statistical relationship with nutritional status.

Recent studies have identified three- and four-factor models for women's empowerment in sub-Saharan Africa that resemble our dimensions for social independence, role in household decision-making, and rejection of IPV.[32,50–52] Jones and colleagues used structural equation modelling to assess the relationship between married women's (15-49) empowerment and nutritional status in five East African countries.[21] Their model included the three domains listed above and found significant positive associations between all three domains and women's BMI, and between role in household decision-making' and haemoglobin. We were unable to identify a statistically significant association between household decision-making and adolescent girls' nutrition, but this measure may be less meaningful for married adolescent girls as they are less likely to hold sway in the household compared to adult women, their husbands, and in-laws.

There is limited understanding of how variations in age and context affect girls' empowerment.[12] While our data included older adolescents, we were able to explore the influence of selected contextual factors on empowerment and nutrition. Our initial model did not include pathways from covariates representing household wealth and country of residence to empowerment dimensions, but the models' modifications indices recommended the addition of these paths to reflect the significant relationship between these contextual measures and empowerment. Context-specific structural characteristics, such socio-economic status and gendered norms, beliefs, and practices, can constrain girls' choices and influence their behaviour, values, and preferences. Geographic measures, such as country of residence, can act as proxy

indicators for engrained rules, norms and practices that shape girls' agency.[23] Others have similarly found that levels of empowerment vary by country and household wealth.[21,50,53] Existing models of adolescent empowerment recognize that supportive laws, policies, structures, and adults/decision-makers are a crucial influence on pathways from adolescent empowerment to improved health and well-being.[11,12,54] These relationships undoubtedly vary by household, community, region, and state, and must be examined when seeking to design and measure meaningful empowerment-related change. In East Africa, continued high rates of HIV infection among adolescents, especially girls, is an important contextual factor given the intersection of the HIV/AIDS epidemic and adolescent health seeking behaviour in this region.[55]

Our greatest limitation was data availability. There are few choices for researchers seeking datasets that include both gender-related and health-related data. The DHS is one of the few options available, but it is not designed for analyses of adolescent populations and does not collect data for younger adolescents (aged 10-14 years), nor does it collect the women's status module for unmarried adolescents. We were unable to test single country models because of small country sample sizes for our target population, and our results suggest that this would be meaningful given country of residence is directly related to empowerment. The DHS also lacks measures for other potentially important empowerment dimensions and confounders of the nutrition-empowerment relationship. We included as many relevant and available empowerment indicators and covariates as possible and maximized our sample by pooling country datasets to form a regional sample to overcome these limitations. However, we still had two dimensions measured by only two indicators, which led to the elimination of both dimensions in the BMI-for-age because of model instability. One benefit of using DHS data is that this model can be used to test the association of dimensions of empowerment with other health outcomes and across contexts due to the DHS standardized format that allows cross-country and -time comparisons.

Our findings suggest that investment in girls' access to information through education and mass/social media remains an important strategy for their empowerment and nutrition. Others have similarly argued that investing in secondary education, particularly for girls, provides extensive opportunities for health and well-being.[56] This will require investments in interventions that address some of the greatest gender-related barriers to girls' education, including restrictive gender norms that devalue girls' education, cultural practices of child/early/forced marriage and early pregnancy, and inadequate water and sanitation facilities in schools. Schools can also serve as important platforms for health promotion and services, such as nutrition education and iron and folic acid supplementation.[11]

Recent evidence points to the value of social media for addressing overnutrition. Increasing rates of overweight and obesity in the region signal the need to invest in these areas as well. However, low access

to digital technology in the region could be an impediment.[57] Caution should also be exercised given the potentially negative influence of social media on body image and the ability of industry to directly market unhealthy food and beverage choices to adolescents through various media platforms.[7,49]

The economic empowerment of adolescent girls is receiving increasing attention, whether it is through examining gender disparities in economic opportunities between adolescent boys and girls [58], or the incorporation of economic empowerment strategies such as income generating activities, savings and loan programs, and life skills training in adolescent nutrition interventions.[59,60] Our findings suggest that adolescent girls' economic empowerment may influence their haemoglobin levels, but we could not test this relationship for BMI-for-age due to modelling limitations. Others have found equivocal results on the economic empowerment and nutrition link for adolescent girls as well.[59] More investigation is warranted.

There is an urgent need for better data on adolescent empowerment and health to facilitate research on the gendered pathways to better health for adolescents. This includes the need for datasets to be sufficiently powered to analyse other socially stratifying factors such as ethnicity and disability, and more balanced data that captures gender-related measures for boys and girls.[58,59,61,62] Much work remains to further our understanding of the mechanisms of action that link adolescent girls' empowerment and nutrition. Studies that assess causality and further our options for validated measures across contexts are needed. This latter point cannot replace the importance of understanding the role of context in the empowerment process, such as the reasons behind varying levels of empowerment by country. The use of statistical models should be complemented by robust qualitative research to further results interpretation.

List of abbreviations

BMI	Body mass index
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
DHS	Demographic and Health Survey
EFA	Exploratory factor analysis
ESEM	Exploratory structural equation model

Hb	Haemoglobin
HIV	Human immunodeficiency virus
IPV	Intimate partner violence
IRB	Institutional Review Board
RMSEA	Root mean square error of approximation
SD	Standard deviation
SEM	Structural equation model
SRMR	Standardized root mean square residual
TLI	Tucker-Lewis index
UGM	Unweighted grand mean
WHO	World Health Organization
WLSMV	Variance-adjusted weighted least squares
ZBFA	BMI-for-age z-score

Declarations

Ethic approval and consent to participate

The DHS Program maintains strict standards for protecting the privacy of respondents and household members in all DHS surveys. All data are anonymized before use. Procedures and questionnaires for standard DHS surveys have been reviewed and approved by ICF Institutional Review Board (IRB). Country-specific DHS survey protocols are reviewed by the ICF IRB and typically by an IRB in the host country. Permission to access the raw data was provided by the DHS Program. Informed consent was obtained from all respondents in the survey before asking questions, and separately before obtaining biomarker and anthropometric measurements. Respondents who did not provide consent were excluded from the analysis for the current study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed during the current study are available from the Demographic and Health Survey Program, https://dhsprogram.com/Data/ .

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AYR conceived the study and wrote the original draft. AYR, WL, GAW, and VW verified the underlying data. AYR, WL, ZAB, MT, CV, EK, GAW, VW contributed to the study methodology. AYR with support from WL conducted the investigation and formal analyses with supervision from GAW and VW. All authors contributed to the review and editing of the article. AYR, GAW, and VW secured funding for the study. All authors had final responsibility for the decision to submit for publication.

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Not applicable.

Additional materials

Additional materials related to this study's methods and results, such as unstandardized path coefficients, that referenced in this manuscript can be found in Additional File 1 (docx file).

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TABLES

Table 1. Demographic characteristics and nutritional status of married adolescent girls (15-19 years) from Demographic and Health Surveys conducted in Ethiopia (2016), Kenya (2014), Tanzania (2015-16), and Uganda (2016).

Variable	Regional (n = 1,927)	Ethiopia (n = 664)	Kenya (n = 352)	Tanzania (n = 619)	Uganda (n = 292)
Mean age (SD)	17.9 (1.1)	17.7 (1.1)	18.0 (1.1)	17.9 (1.2)	18.1 (1.0)
Mean level of completed education (SD)	5.1 (3.4)	3.8 (3.5)	6.5 (3.6)	5.4 (3.0)	5.9 (2.5)
Living in an urban setting, % (n)	19.8 (381)	16.7 (111)	33.8 (119)	17.6 (109)	14.4 (42)
Household wealth below the middle quintile, % (n)	57.6 (1,109)	56.3 (374)	60.8 (214)	55.7 (345)	60.3 (176)
Currently pregnant, % (n)	21.6 (416)	16.1 (107)	22.7 (80)	25.5 (158)	24.3 (71)
Currently breastfeeding, % (n)	41.7 (804)	33.1 (220)	50.3 (175)	43.6 (270)	47.6 (139)
Anemic (Hb < 12.0g/dl, <11.0g/dl (preg)), % (n) [a]	43.8 (664)	32.3 (198)	NA	57.1 (350)	40.1 (116)
Mean BMI (SD) [b]	20.8 (3.1)	19.7 (3.0)	21.0 (3.1)	21.6 (3.3)	21.4 (2.4)
Thin (ZBFA < -2SD), % (n)	3.5 (52)	7.8 (41)	2.6 (7)	0.9 (4)	0.0 (0)
Overweight or obese (ZBFA > 1SD), % (n)	7.0 (103)	3.0 (16)	9.9 (27)	9.0 (41)	8.7 (19)

BMI = Body Mass Index.

NA = Not Available. Kenya DHS (2014) did not conduct anemia testing.

SD = Standard Deviation.

ZBFA = BMI-for-age z-score.

[a] Total sample size for anemia testing = 1,515.

[b] Total sample size for anthropometric measures = 1,476.

Table 2. Empowerment indicator means, proportions, and factor loadings.[a]

Indicator name	Mean value or proportion 'empowered' n = 1,927	F1	F2	F3	F4	F5	F6
Dimension 1: Access to information							
Completed level of education, mean (SD)	5.1 (3.4)	**0.570**	0.050	0.032	0.084	-0.072	0.150
Watches TV, % (n)	28.5 (549)	**0.635**	0.117	0.039	0.004	-0.091	-0.013
Reads newspaper or magazine, % (n)	18.9 (364)	**0.763**	-0.181	0.016	-0.011	0.003	0.048
Listens to the radio, % (n)	55.0 (1060)	**0.771**	0.025	-0.155	0.004	0.060	-0.035
Dimension 2: Barriers to healthcare							
Getting permission, % (n)	81.4 (1569)	0.002	**0.876**	-0.070	0.017	0.040	0.014
Money, % (n)	54.8 (1056)	0.074	**0.737**	0.021	-0.016	-0.010	-0.024
Distance, % (n)	55.6 (1072)	0.020	**0.878**	0.046	-0.042	-0.037	-0.016
Going alone, % (n)	69.4 (1337)	-0.027	**0.840**	-0.007	0.046	0.024	0.035
Dimension 3: Social independence							
Age at 1st marriage, mean (SD)	16.0 (1.6)	0.053	0.004	-0.038	0.008	0.011	**0.895**
Age at 1st sex, mean (SD)	15.5 (1.7)	0.051	-0.012	0.057	-0.023	0.001	**0.693**
Partner age difference, mean (SD)	-7.4 (4.6)	E	E	E	E	E	E
Partner education difference, mean (SD)	-1.1 (3.7)	E	E	E	E	E	E
Dimension 4: Asset ownership		E	E	E	E	E	E
Earns a cash income, % (n)[b]	28.1 (541)	E	E	E	E	E	E
Owns house alone or jointly, % (n)	39.5 (761)	-0.091	-0.015	0.022	-0.003	**0.827**	0.013
Owns land alone or jointly, % (n)	32.9 (633)	0.033	0.030	0.000	0.006	**0.998**	-0.004
Dimension 5: Role in HH decision-making							
Own healthcare, % (n)	67.6 (1301)	0.099	-0.031	**0.831**	-0.022	0.004	0.008

HH purchases, % (n)	52.3 (1007)	-0.034	0.007	**0.929**	0.013	0.043	-0.024
Visits to family and friends, % (n)	62.1 (1195)	-0.166	0.075	**0.795**	0.060	-0.086	0.042
Use of husband income, % (n)	57.45 (1103)	0.097	-0.046	**0.742**	-0.039	0.081	-0.034
Dimension 6: Rejects IPV							
Goes out without permission, % (n)	55.0 (1059)	-0.035	0.051	0.043	**0.881**	-0.009	-0.029
Burns food, % (n)	72.9 (1404)	0.233	0.030	-0.037	**0.743**	-0.026	0.027
Neglects child, % (n)	48.4 (933)	-0.031	-0.066	-0.006	**0.938**	0.045	-0.046
Refuses sex, % (n)	64.5 (1243)	0.141	-0.016	-0.005	**0.820**	0.010	0.030
Argues with husband, % (n)	53.2 (1025)	-0.001	0.004	0.026	**0.885**	-0.022	0.020

E = Eliminated. Indicator was eliminated from the final model because its did not meet the pre-established cut-off.

HH = Household.

IPV = Intimate Partner Violence.

SD = Standard Deviation.

[a] A factor loading is the percentage of an indicator's variability explained by a given factor (empowerment dimension).

[b] Proportion of respondents who earned any cash income.

Table 3. Standardized path coefficients and adjusted odds ratios with95% confidence intervals for nutrition outcomes by empowerment dimension.

Outcome	Access to info	Access to HC	HH decision-making	Rejection of IPV	Social independence	Asset ownership
Hb	0.078 (-0.031, 0.187)	0.020 (-0.060, 0.101)	0.029 (-0.053, 0.110)	0.040 (-0.041, 0.120)	-0.030 (-0.098, 0.037)	**0.148** **(0.061, 0.235)**
Anemia[a]	1.005 (0.866, 1.168)	1.015 (0.918, 1.123)	0.966 (0.862, 1.083)	0.989 (0.888, 1.101)	1.046 (0.958, 1.143)	0.928 (0.816, 1.053)
Mod.-sev. anemia[a]	0.872 (0.730, 1.042)	0.974 (0.863, 1.100)	0.954 (0.843, 1.081)	0.905 (0.796, 1.028)	1.046 (0.951, 1.150)	**0.817** **(0.716, 0.933)**
ZBFA	**0.188** **(0.075, 0.301)**	-0.016 (-0.104, 0.072)	-0.028 (-0.112, 0.055)	0.036 (-0.044, 0.116)	NA	NA
Overweight or obese[a]	1.203 (0.976, 1.481)	0.989 (0.837, 1.169)	0.913 (0.775, 1.076)	**1.168** **(1.026, 1.330)**	NA	NA
Thinness[a]	0.558 *	1.088 *	1.079 *	1.184 *	NA	NA

[a] Adjusted odds ratio.
* Confidence intervals too wide to report here.
95%CI = 95% confidence interval.
Bolded = $p < 0.05$.
Hb = Haemoglobin (g/dL).
HC = Healthcare.
HH = Household.
IPV = Intimate Partner Violence.
NA = Not Applicable.
ZBFA = BMI-for-age z-score.

FIGURES

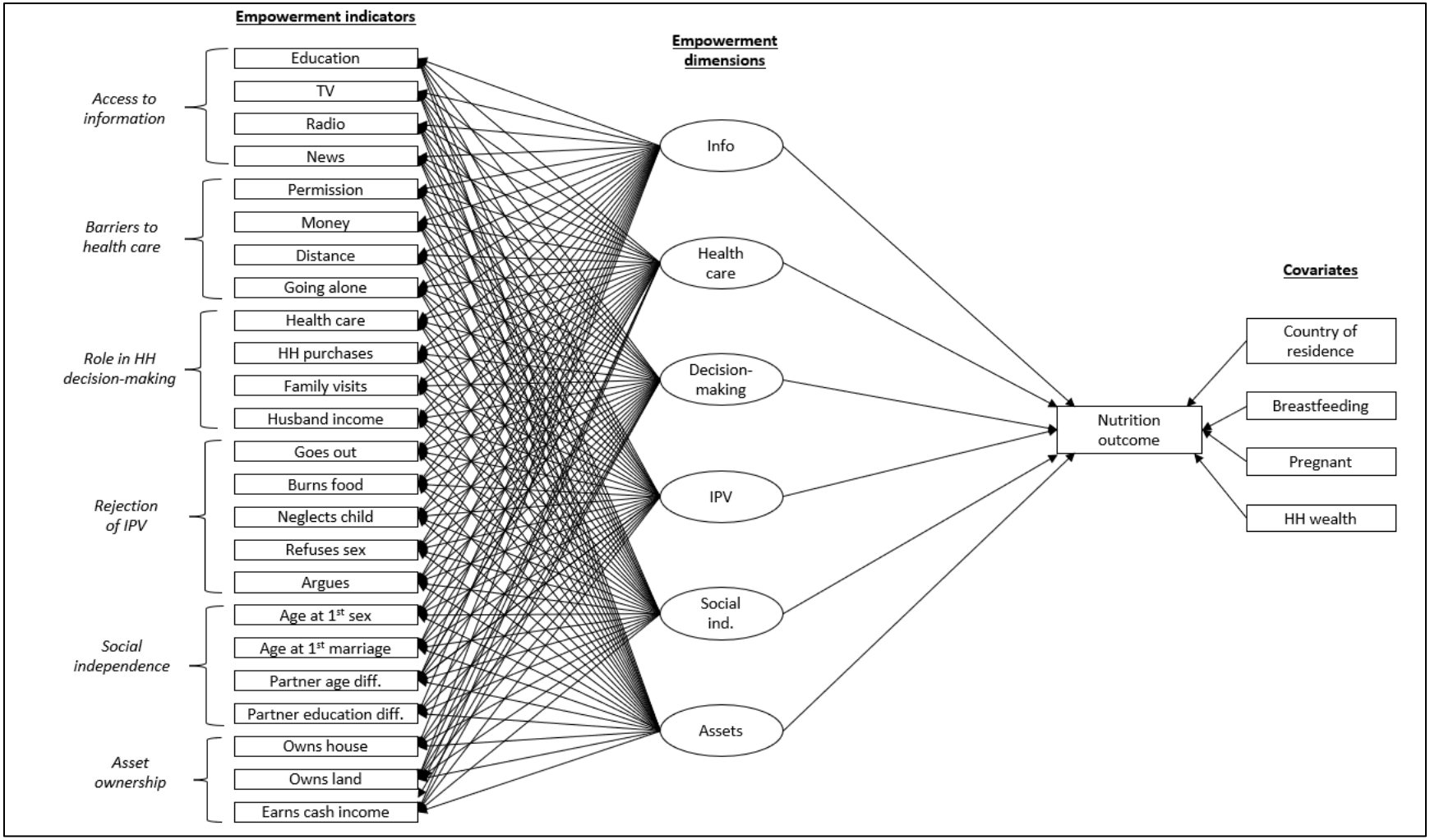

Empowerment indicators
Empowerment dimensions
Access to information
Education
TV
Radio
News
Barriers to health care
Permission
Money
Distance
Going alone
Role in HH decision-making
Health care
HH purchases
Family visits
Husband income
Rejection of IPV
Goes out
Burns food
Neglects child
Refuses sex
Argues
Social independence
Age at 1st sex
Age at 1st marriage
Partner age diff.
Partner education diff.
Asset ownership
Owns house
Owns land
Earns cash income
Info
Health care
Decision-making
IPV
Social ind.
Assets
Nutrition outcome
Covariates
Country of residence
Breastfeeding
Pregnant
HH wealth

Figure 1. Exploratory structural equation model of the relationship between dimensions of empowerment and nutrition status, controlling for important covariates.

Notes: Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment dimensions). Unidirectional arrows represent direct effects of exposure on outcome. The lefthand side of the model is an exploratory factor analysis of empowerment indicators to define the underlying factor structure (empowerment dimensions). The righthand side of the model is a regression analysis of a nutritional outcome on empowerment dimensions. Both sides of the model are estimated simultaneously. Not shown: Error terms for estimated variables, covariance of factors.

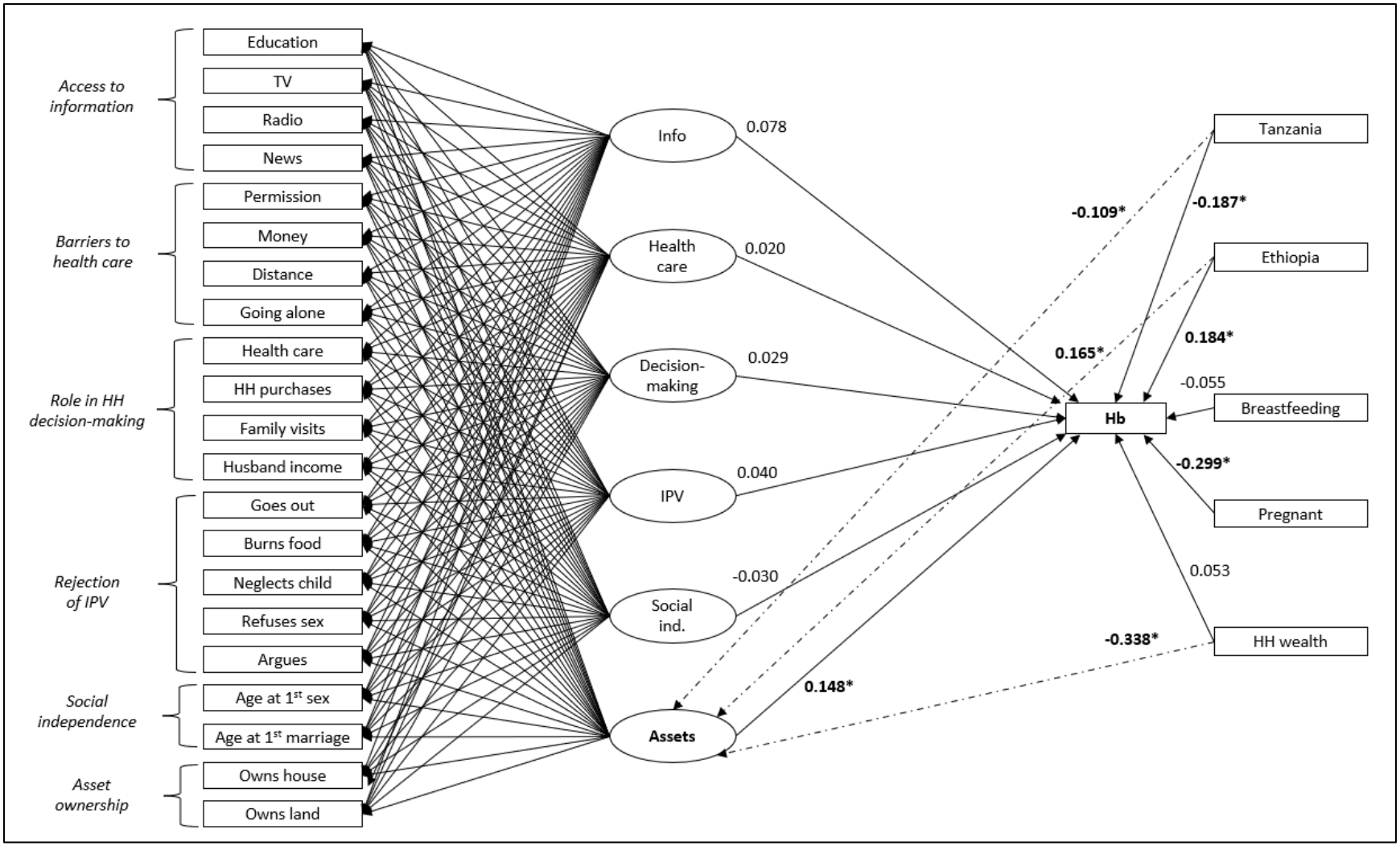

Access to information
Education
TV
Radio
News
Barriers to health care
Permission
Money
Distance
Going alone
Role in HH decision-making
Health care
HH purchases
Family visits
Husband income
Rejection of IPV
Goes out
Burns food
Neglects child
Refuses sex
Argues
Social independence
Age at 1st sex
Age at 1st marriage
Asset ownership
Owns house
Owns land
Info
Health care
Decision-making
IPV
Social ind.
Assets
0.078
0.020
0.029
0.040
-0.030
Hb
Tanzania
Ethiopia
Breastfeeding
Pregnant
HH wealth
-0.109*
-0.187*
0.165*
0.184*
-0.055
-0.299*
0.053
-0.338*
0.148*

Figure 2. Final exploratory structural equation model of the relationship between married adolescent girls' haemoglobin levels and empowerment dimensions.

Notes: Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment dimensions). Unidirectional arrows represent direct effect of exposure on outcome. Values are standardized beta coefficients for respective paths. Bolded values are significant at the 0.05 level. Only statistically significant paths and values are presented. Paths indicated by a dotted line were added to the model following a review of modification indices. Similar paths from household wealth and countries of residence to the remaining empowerment dimensions were statistically significant but are not shown to simplify figure interpretation. Not shown: Error terms for estimated variables, covariance of factors.

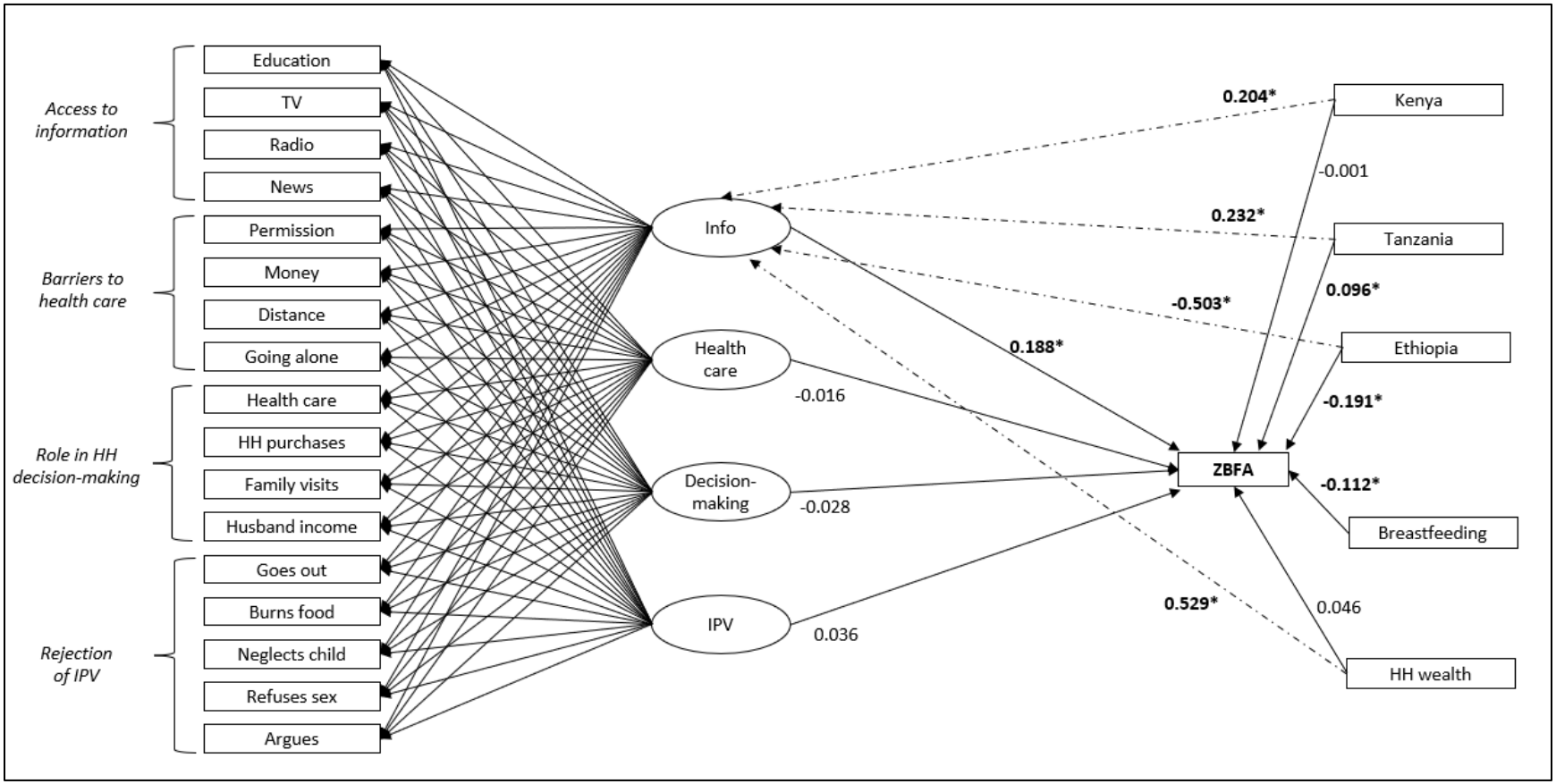


Figure 3. Final exploratory structural equation model of the relationship between married adolescent girls' BMI-for-age and empowerment dimensions.

ADDITIONAL FILE 1

List of selected empowerment studies using DHS data

1. Asaolu, I. O., Alaofè, H., Gunn, J. K. L., Adu, A. K., Monroy, A. J., Ehiri, J. E., Hayden, M. H., & Ernst, K. C. (2018). Measuring Women's Empowerment in Sub-Saharan Africa: Exploratory and Confirmatory Factor Analyses of the Demographic and Health Surveys. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.00994
2. Asaolu, I. O., Okafor, C. T., Ehiri, J. C., Dreifuss, H. M., & Ehiri, J. E. (2017). Association between Measures of Women's Empowerment and Use of Modern Contraceptives: An Analysis of Nigeria's Demographic and Health Surveys. Frontiers in Public Health, 4. https://doi.org/10.3389/fpubh.2016.00293
3. Ballon, P. (2018). A Structural Equation Model of Female Empowerment. The Journal of Development Studies, 54(8), 1303–1320. https://doi.org/10.1080/00220388.2017.1414189
4. Doku, D. T., Bhutta, Z. A., & Neupane, S. (2020). Associations of women's empowerment with neonatal, infant and under-5 mortality in low- and /middle-income countries: meta-analysis of individual participant data from 59 countries. BMJ Global Health, 5(1), e001558. https://doi.org/10.1136/bmjgh-2019-001558
5. Ewerling, F., Lynch, J. W., Victora, C. G., van Eerdewijk, A., Tyszler, M., & Barros, A. J. D. (2017). The SWPER index for women's empowerment in Africa: development and validation of an index based on survey data. The Lancet Global Health, 5(9), e916–e923. https://doi.org/10.1016/S2214-109X(17)30292-9
6. Ewerling, F., Raj, A., Victora, C. G., Hellwig, F., Coll, C. V. N., & Barros, A. J. D. (2020). SWPER Global: A survey-based women's empowerment index expanded from Africa to all low- and middle-income countries. JOURNAL OF GLOBAL HEALTH, 10(2). https://doi.org/10.7189/jogh.10.020434
7. Jennings, L., Na, M., Cherewick, M., Hindin, M., Mullany, B., & Ahmed, S. (2014). Women's empowerment and male involvement in antenatal care: analyses of Demographic and Health Surveys (DHS) in selected African countries. BMC Pregnancy and Childbirth, 14(1), 297. https://doi.org/10.1186/1471-2393-14-297

8. Jones, R. E., Haardörfer, R., Ramakrishnan, U., Yount, K. M., Miedema, S. S., Roach, T. D., & Girard, A. W. (2020). Intrinsic and instrumental agency associated with nutritional status of East African women. Social Science & Medicine, 247, 112803. https://doi.org/10.1016/j.socscimed.2020.112803
9. Jones, R., Haardörfer, R., Ramakrishnan, U., Yount, K. M., Miedema, S., & Girard, A. W. (2019). Women's empowerment and child nutrition: The role of intrinsic agency. SSM - Population Health, 9, 100475. https://doi.org/10.1016/j.ssmph.2019.100475
10. Kabir, A., Rashid, M. M., Hossain, K., Khan, A., Sikder, S. S., & Gidding, H. F. (2020). Women's empowerment is associated with maternal nutrition and low birth weight: evidence from Bangladesh Demographic and Health Survey. BMC Women's Health, 20(93).
11. Kishor, S., & Subaiya, L. (2008). Understanding Women's Empowerment: A Comparative Analysis of Demographic and Health Surveys (DHS) Data. In DHS Comparative Reports No. 20.
12. Miedema, S. S., Haardörfer, R., Girard, A. W., & Yount, K. M. (2018). Women's empowerment in East Africa: Development of a cross-country comparable measure. World Development, 110, 453–464. https://doi.org/10.1016/j.worlddev.2018.05.031
13. Na, M., Jennings, L., Talegawkar, S. A., & Ahmed, S. (2015). Association between women's empowerment and infant and child feeding practices in sub-Saharan Africa: an analysis of Demographic and Health Surveys. Public Health Nutrition, 18(17), 3155–3165. https://doi.org/10.1017/S1368980015002621
14. Pratley, P., & Sandberg, J. F. (2018). Refining the Conceptualization and Measurement of Women's Empowerment in Sub-Saharan Africa Using Data from the 2013 Nigerian Demographic and Health Survey. Social Indicators Research, 140(2), 777–793. https://doi.org/10.1007/s11205-017-1811-1
15. Sebayang, S. K., Efendi, F., & Astutik, E. (2017). Women's empowerment and the use of antenatal care services in Southeast Asian countries. In DHS Working Papers No. 129. http://dhsprogram.com/pubs/pdf/WP129/WP129.pdf
16. Shimamoto, K., & Gipson, J. D. (2017). Examining the mechanisms by which women's status and empowerment affect skilled birth attendant use in Senegal: a structural equation modeling approach. BMC Pregnancy and Childbirth, 17(S2), 341. https://doi.org/10.1186/s12884-017-1499-x
17. Shimamoto, K., & Gipson, J. D. (2019). Investigating pathways linking women's status and empowerment to skilled attendance at birth in Tanzania: A structural equation modeling approach. PLOS ONE, 14(2), e0212038. https://doi.org/10.1371/journal.pone.0212038

18. Yaya, S., Odusina, E. K., Uthman, O. A., & Bishwajit, G. (2020). What does women's empowerment have to do with malnutrition in Sub-Saharan Africa? Evidence from demographic and health surveys from 30 countries. Global Health Research and Policy, 5(1), 1. https://doi.org/10.1186/s41256-019-0129-8

Table A1. Model indicator descriptions and coding.

DHS variable name	DHS variable description	Recode name	Recode description
v133	Education in single years Constructed from the education level (v106) and the grade at that level (v107)	educ	Recoded to replace zero values with missing "."
V157	Frequency of reading newspaper or magazine 0 = "Not at all" 1 = "Less than once a week" 2 = "At least once a week" 3 = "Almost every day"	News	1 = reads less than once per week or more 0 = not at all
v158	Frequency of listening to radio 0 = "Not at all" 1 = "Less than once a week" 2 = "At least once a week" 3 = "Almost every day"	Radio	1 = listens less than once per week or more 0 = not at all
v159	Frequency of watching TV 0 = "Not at all" 1 = "Less than once a week" 2 = "At least once a week" 3 = "Almost every day"	TV	1 = watches less than once per week or more 0 = not at all
v190	Wealth index 1 = "Poorest" 2 = "Poorer" 3 = "Middle" 4 = "Richer" 5 = "Richest"	--	--
v191	Wealth index factor score (5 decimals)	wealth	Recoded to add 5 decimal spaces
v213	Currently pregnant	--	--

DHS variable name	DHS variable description	Recode name	Recode description
	0 = "No or unsure" 1 = "Yes"		
v404	Currently breastfeeding 0 = No 1 = Yes	--	--
v437	Respondent's weight (kg) (1 decimal)	wgt	Recoded to add 1 decimal place
v438	Respondent's height (cm) (1 decimal)	hgt	Recoded to add 1 decimal place
v445		CBMI	Calculated using AnthroPlus
		ZBFA	Calculated using AnthroPlus
		thin	1 = "Thin" (ZBFA <= -2) 0 = "Not thin" (ZBFA > -2)
		overwgt	1 = "Overweight or obese" (ZBFA > 1) 0 = "Not overweight or obese" (ZBFA <= 1)
v456	Hb level adjusted for altitude and smoking (g/dL) (1decimal)	hb	Recoded to add 1 decimal place
v457	Anemia status 1 = "Severe" 2 = "Moderate" 3 = "Mild" 4 = "Not anemic" Any anemia: · Number of non-pregnant women whose hemoglobin count is less than 12.0 grams per deciliter (g/dl) (v456 < 120) · plus number of pregnant women whose count is less than 11.0 g/dl (v456 < 110) 2) Mild anemia: · Number of non-pregnant women whose hemoglobin count is between 11.0	Anemia	1 = (v456 < 120) or (v456 < 110 for pregnant respondents) 0 = Not anemic

DHS variable name	DHS variable description	Recode name	Recode description
	and 11.9 g/dl (v456 in 110:119) · plus number of pregnant women whose hemoglobin count is between 10.0 and 10.9 g/dl (v456 in 100:109) 3) Moderate anemia: · Number of non-pregnant women whose hemoglobin count is between 8.0 and 10.9 g/dl (v456 in 80:109) · Number of pregnant women whose hemoglobin count is between 7.0 and 9.9 g/dl (v456 in 70:99) 4) Severe anemia: · Number of non-pregnant women whose hemoglobin count is less than 8.0 g/dl (v456<80) · Number of pregnant women whose hemoglobin count is less than 7.0 g/dl (v456<70)		
		Mod to sev anemia	1 = (v456 < 110) or (v456 < 100 for pregnant respondents) 0 = Not moderately to severely anemic
v467b	Permission is a barrier to health care for self 0 = "No problem" 1 = "Big problem" 2 = "Not a big problem"	permis	1 = No problem or not a big problem 0 = big problem
v467c	Money is a barrier to health care for self 0 = "No problem" 1 = "Big problem" 2 = "Not a big problem"	money	1 = No problem or not a big problem 0 = big problem
v467d	Distance is a barrier to health care for self 0 = "No problem"	distance	1 = No problem or not a big problem 0 = big problem

DHS variable name	DHS variable description	Recode name	Recode description
	1 = "Big problem" 2 = "Not a big problem"		
v467f	Going alone is a barrier to health care for self 0 = "No problem" 1 = "Big problem" 2 = "Not a big problem"	alone	1 = No problem or not a big problem 0 = big problem
v511	Age at first union	--	--
v531	Age at first sex (imputed)	--	--
v715	Partner education level	--	--
v730	Partner age	--	--
v741	Type of earnings 0 = "Not paid" 1 = "Cash only" 2 = "Cash and in-kind" 3 = "In-kind only"	earnings	2 = Cash and in-kind or cash only 1 = in-kind only 0 = not paid
v743a	Person who decides on health care 1 = "Respondent alone" 2 = "Respondent and husband/partner" 3 = "Respondent and other person" 4 = "Husband/partner alone" 5 = "Someone else" 6 = "Other"	health	1 = Decides alone or jointly (with husband or other) 0 = no role in decision-making
v743b	Person who decided on large HH purchases 1 = "Respondent alone" 2 = "Respondent and husband/partner" 3 = "Respondent and other person" 4 = "Husband/partner alone" 5 = "Someone else" 6 = "Other"	purchase	1 = Decides alone or jointly (with husband or other) 0 = no role in decision-making

DHS variable name	DHS variable description	Recode name	Recode description
v743d	Person who decides on visits to friends and family 1 = "Respondent alone" 2 = "Respondent and husband/partner" 3 = "Respondent and other person" 4 = "Husband/partner alone" 5 = "Someone else" 6 = "Other"	visit	1 = Decides alone or jointly (with husband or other) 0 = no role in decision-making
v743f	Person who decided on husband's income 1 = "Respondent alone" 2 = "Respondent and husband/partner" 3 = "Respondent and other person" 4 = "Husband/partner alone" 5 = "Someone else" 6 = "Other" 7 = "Husband/partner has no earnings"	husband	1 = Decides alone or jointly (with husband or other) 0 = no role in decision-making
v744a	Going out without tell husband is justification for violence 0 = "No" 1 = "Yes" 8 = "Don't know"	out	1 = No 0 = Yes or don't know
v744b	Neglecting children is justification for violence 0 = "No" 1 = "Yes" 8 = "Don't know"	neglect	1 = No 0 = Yes or don't know
v744c	Arguing with husband is justification for violence 0 = "No" 1 = "Yes" 8 = "Don't know"	argue	1 = No 0 = Yes or don't know
v744d	Refusing sex is justification for violence 0 = "No"	refuse	1 = No 0 = Yes or don't know

DHS variable name	DHS variable description	Recode name	Recode description
	1 = "Yes" 8 = "Don't know"		
v744e	Burning food is justification for violence 0 = "No" 1 = "Yes" 8 = "Don't know"	burns	1 = No 0 = Yes or don't know
v745a	Owns a house	house	1 = Owns house alone or jointly 0 = Does not own
v745b	Owns land	land	1 = Owns land alone or jointly 0 = Does not own
--	--	country	11 = "Ethiopia" 22 = "Tanzania" 33 = "Kenya" 44 = "Uganda" 55 = "Rwanda"

Table A2. Unstandardized path coefficients with 95% confidence intervals for nutrition outcomes by empowerment dimension.

Outcome	N	Access to info	Access to HC	HH decision-making	Rejection of IPV	Social Independence	Asset ownership
Haemoglobin (g/dL)	1575	0.111 (-0.042, 0.264)	0.036 (-0.106, 0.178)	0.050 (-0.092, 0.192)	0.074 (-0.077, 0.225)	-0.056 (-0.182, 0.069)	**0.262 (0.108, 0.415)**
Anemia[a]	1575	0.004 (-0.116, 0.124)	0.015 (-0.086, 0.116)	-0.034 (-0.034, -0.147)	-0.012 (-0.125, 0.101)	0.048 (-0.045, 0.141)	-0.075 (-0.202, 0.051)
Mod.-sev. anemia[b]	1575	-0.108 (-0.248, 0.032)	-0.026 (-0.145, 0.093)	-0.046 (-0.166, 0.075)	-0.104 (-0.237, 0.029)	0.046 (-0.052, 0.145)	**-0.198 (-0.327, -0.069)**
BMI-for-age (z-score)	1511	**0.113 (0.045, 0.181)**	-0.012 (-0.080, 0.055)	-0.023 (-0.092, 0.045)	0.031 (-0.037, 0.099)	NA	NA
Overweight[c]	1511	0.134 (-0.018, 0.286)	-0.010 (-0.165, 0.144)	-0.090 (-0.253, 0.072)	**0.161 (0.028, 0.293)**	NA	NA
Thinness[d]	1511	-0.412 (-1.181, 0.0357)	0.075 (-0.239, 0.389)	0.073 (-0.339, 0.486)	0.170 (-0.555, 0.894)	NA	NA

Bolded = $p < 0.05$.
BMI = Body mass index.
CI = Confidence Interval.
HC = Health Care.
HH = Household.
IPV = Intimate Partner Violence.
NA = Not Available.
[a] Hb < 12.0 g/dl for non-pregnant, Hb < 11.0 for pregnant.
[b] Hb < 11.0 g/dl for non-pregnant, H1 < 10.0 for pregnant.
[c] ZBFA > 1SD.
[d] ZBFA < -2SD.

Table A3. Standardized path coefficients with 95% confidence intervals for nutrition outcomes by empowerment dimension.

Outcome	N	Access to info	Access to HC	HH decision-making	Rejection of IPV	Social Independence	Asset ownership
Haemoglobin (g/dL)	1575	0.078 (-0.031, 0.187)	0.020 (-0.060, 0.101)	0.029 (-0.053, 0.110)	0.040 (-0.041, 0.120)	-0.030 (-0.098, 0.037)	**0.148 (0.061, 0.235)**
Anemia[a]	1575	0.005 (-0.144, 0.155)	0.015 (-0.086, 0.116)	-0.035 (-0.149, 0.080)	-0.011 (-0.119, 0.096)	0.045 (-0.043, 0.134)	-0.075 (-0.203, 0.052)
Mod.-sev. anemia[b]	1575	-0.137 (-0.315, 0.041)	-0.026 (-0.147, 0.095)	-0.047 (-0.171, 0.078)	-0.100 (-0.228, 0.028)	0.045 (-0.050, 0.140)	**-0.202 (-0.334, -0.069)**
BMI-for-age (z-score)	1511	**0.188 (0.075, 0.301)**	-0.016 (-0.104, 0.072)	-0.028 (-0.112, 0.055)	0.036 (-0.044, 0.116)	NA	NA
Overweight[c]	1511	0.185 (-0.024, 0.393)	-0.011 (-0.178, 0.156)	-0.091 (-0.255, 0.073)	**0.155 (0.026, 0.285)**	NA	NA
Thinness[d]	1511	-0.583 (-199.532, 198.366)	0.084 (-28.414, 28.581)	0.076 (-25.414, 26.070)	0.169 (-57.386, 57.723)	NA	NA

Bolded = $p < 0.05$.
BMI = Body mass index.
CI = Confidence Interval.
HC = Health Care.
HH = Household.
IPV = Intimate Partner Violence.
NA = Not Available.
[a] Hb < 12.0 g/dl for non-pregnant, Hb < 11.0 for pregnant.
[b] Hb < 11.0 g/dl for non-pregnant, H1 < 10.0 for pregnant.
[c] ZBFA > 1SD.
[d] ZBFA < -2SD.

Table A4. Model fit results.

Model	Chi-square value (df) p-value	RMSEA	CFI	TLI	SRMR
BMI-for-age	436.624 (156) 0.0000	0.035	0.954	0.929	0.049
Haemoglobin	437.478 (201) 0.0000	0.027	0.966	0.942	0.042
Anemia	435.596 (201) 0.0000	0.027	0.966	0.942	0.043
Mod to sev anemia	439.189 (201) 0.0000	0.027	0.965	0.941	0.043
Overweight	430.124 (156) 0.0000	0.034	0.955	0.930	0.049
Thin	353.129 (156) 0.0000	0.029	0.965	0.945	0.081

BMI = Body mass index.
CFI = Confirmatory Factor Index.
df = Degrees of freedom.
RMSEA = Root Mean Square Error Approximation.
SRMR = Standardized Root Mean Square Residual.
TLI = Tucker Lewis Index.

Table A5. Standardized path coefficients and 95% confidence intervals for nutrition outcomes by empowerment domain for models including additional covariates.[3]

Outcome	Access to info	Access to HC	HH decision-making	Rejection of IPV	Social independence	Asset ownership
Hb	0.074	0.019	0.033	0.054	-0.053	**0.138**
95%CI	(-0.038, 0.187)	(-0.062, 0.101)	(-0.053, 0.119)	(-0.025, 0.133)	(-0.129, 0.023)	**(0.049, 0.227)**
ZBFA	**0.212**	-0.027	-0.027	0.046	-0.074	NA
95%CI	**(0.099, 0.324)**	(-0.118, 0.063)	(-0.108, 0.053)	(-0.035, 0.127)	(-0.154, 0.006)	

Bolded = $p < 0.05$.
CI = Confidence interval.
Hb = Haemoglobin (g/dL).
HC = Health care.
HH = Household.
IPV = Intimate Partner Violence.
NA = Not Available.
ZBFA = BMI-for-age z-score.

Table A6. Model fit results for models with additional covariates.

Model	Chi-square value (df) p-value	RMSEA	CFI	TLI	SRMR
BMI-for-age	963.698 (251) 0.0000	0.036	0.909	0.866	0.066
Haemoglobin	986.075 (264) 0.0000	0.036	0.919	0.874	0.074

BMI = Body mass index.
CFI = Confirmatory Factor Index.
df = Degrees of freedom.
RMSEA = Root Mean Square Error Approximation.
SRMR = Standardized Root Mean Square Residual.
TLI = Tucker Lewis Index.

Table A7. Standardized path coefficients and 95% confidence intervals for the direct association of model covariates and empowerment dimensions.

	F1 Info	F2 Health care	F3 Decisions	F4 IPV	F5 Assets	F6 Soc. Indep.
Lives in Ethiopia						
Hb model	-0.462 (-0.531 to -0.393)	-0.237 (-0.318 to -0.155)	0.372 (0.291 to 0.454)	-0.097 (-0.186 to -0.008)	-0.089 (-0.178 to 0.000)	0.165 (0.073 to 0.258)
ZBFA model	-0.503 (-0.578 to -0.429)	-0.373 (-0.458 to -0.288)	0.379 (0.288 to 0.470)	-0.126 (-0.224 to -0.028)	NA	NA
Lives in Kenya						
Hb model	NA	NA	NA	NA	NA	NA
ZBFA model	0.204 (0.140 to 0.268)	0.281 (0.216 to 0.346)	-0.044 (-0.121 to 0.032)	0.131 (0.053 to 0.209)	NA	NA
Lives in Tanzania						
Hb model	0.385 (0.324 to 0.446)	-0.007 (-0.082 to 0.069)	-0.242 (-0.310 to -0.174)	-0.091 (-0.161 to -0.020)	-0.064 (-0.133 to 0.006)	-0.109 (-0.195 to -0.022)
ZBFA model	0.232 (0.167 to 0.297)	-0.107 (-0.175 to -0.038)	-0.218 (-0.289 to -0.147)	-0.164 (-0.236 to -0.092)	NA	NA
Lives in Uganda						
Hb model	0.077	0.244	-0.130	0.188	0.153	-0.056
ZBFA model	0.067	0.199	-0.117	0.159	NA	NA
Household wealth						
Hb model	0.444 (0.377 to 0.511)	0.292 (0.214 to 0.370)	0.086 (0.020 to 0.152)	0.138 (0.074 to 0.201)	-0.338 (-0.416 to -0.259)	0.165 (0.086 to 0.224)
ZBFA model	0.529 (0.474 to 0.584)	0.292 (0.232 to 0.353)	0.049 (-0.016 to 0.114)	0.157 (0.088 to 0.226)	NA	NA

Hb = Haemoglobin.

NA = Not available.

ZBFA = BMI-for-age.

The Kenya covariate was omitted from the Hb model because anemia testing was not conducted during the 2014 Kenya DHS.

CHAPTER 5: Associations between single adolescent girls' empowerment and their nutritional status in East Africa

Chapter overview

Chapter 5 addresses the second research objective presented in Chapter 1: To identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs. The chapter presents a manuscript submitted to *World Development* in October 2022 of a structural equation modelling study that used cross-sectional data from five East African countries to model the relationship between dimensions of empowerment and single (never-married) adolescent girls' nutritional status.

As noted in Chapter 4, we opted to create separate models for single and married adolescent girls for two reasons. First, single versus married adolescent girls likely face different challenges or opportunities to their empowerment and nutrition because they are at different life stages. We wanted to understand how these different life stages affect empowerment and nutrition. Second, our dataset provided more empowerment-related measures for married respondents compared to single respondents. Given the much larger sample size of single adolescent girls, we were able to develop single country models and conduct sub-group analyses that examined differences based on girls' in-school status and geographic location, which we could not do with the married adolescent girl sample.

Manuscript status

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Authors' roles and contributions

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Formal Analysis, Writing – Review and Editing. **George Wells**: Conceptualization, Supervision, Methodology, Formal Analysis, Writing – Review and Editing.

Related thesis appendices

Appendix A3. Mplus Code. An example of the exploratory structural equation modelling code is provided in Appendix A3.

Appendix A4. Mplus output. An example of the exploratory structural equation modelling output is provided in Appendix A4.

Associations between single adolescent girls' empowerment and nutritional status in East Africa: A structural equation modelling study

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Abstract

Adolescent girls have a right to health and nutrition that often goes unfulfilled. Adolescent nutrition frameworks emphasize empowering adolescent girls as an important component of any comprehensive strategy. Previous studies have demonstrated a positive relationship between women's empowerment and maternal and child nutrition. Here, we sought to investigate whether a similar association exists between adolescent girls' empowerment and their nutritional status. We selected an understudied population – single adolescent girls in East Africa – and developed a theoretically-informed structural equation model using validated measures of empowerment from Demographic and Health Surveys conducted in five East African countries. We tested the relationship of three domains of empowerment – the ability to access information, the ability to access healthcare, and the ability to reject intimate partner violence – with girls' BMI-for-age and haemoglobin. We found that girls' ability to access information was positively associated with their BMI-for-age and haemoglobin after controlling for household wealth and country of residence ($p < 0.05$). The remaining domains were not significantly associated with any nutrition outcomes. However, the relationship between girls' empowerment and nutritional status was more complex when subgroup differences (in-school status and geographic location) were examined. The relevant empowerment domains and the magnitude of their relationship with nutritional status changed according to these individual and contextual factors. This finding underscores the importance of identifying context-specific challenges to gender equality, empowerment, and nutrition. Intersectional approaches that consider the unique characteristics of individuals that limit their empowerment and increase their vulnerability to malnutrition need to be incorporated in nutrition intervention design. We suggest that engaging adolescent girls through participatory research and program design should be prioritized to ensure nutrition programs adopt relevant empowerment strategies that meet their needs and priorities.

Keywords: Nutritional Status, Adolescent Girls, East Africa, Empowerment, Gender, Structural Equation Model

Highlights

- The relationship between single adolescent girls' empowerment and nutritional status in East Africa is understudied.
- Overall, improving girls' ability to access information is associated with improvements in their haemoglobin and BMI-for-age.
- The significance of different empowerment domains to girls' nutrition varies according to their geographic location and in-school status.

- Applying an intersectional lens and meaningfully engaging adolescent girls in intervention design using participatory methods is recommended.

Introduction

Adolescent nutrition is an oft-neglected component of the global health agenda. Adolescent-specific nutrition targets are missing from key global commitments, such as the Sustainable Development Goals.[1] Adolescent nutrition has frequently been viewed through the lens of maternal nutrition and focused on preparing adolescent girls for pregnancy and motherhood. However, adolescent girls have a right to health that transcends their reproductive capabilities.[2]

Adolescence is a critical window for growth and development that affects the health and well-being of current and future generations. Globally, levels of underweight and micronutrient deficiencies among adolescent girls have stubbornly persisted, and rates of overweight and obesity are rising.[3] Poor nutrition during adolescence has negative consequences for musculoskeletal growth, cardiovascular fitness, neurodevelopment, and immunity, and increases non-communicable disease risk.[4] It can also reduce educational performance and work productivity in adulthood.[5,6] Malnutrition during adolescent pregnancy increases the risk of maternal mortality, stillbirth, preterm birth, small-for-gestational-age babies, and low birth weight.[7] Among breastfeeding mothers, poor nutrition can have significant negative effects on both the mother and on the survival, growth, and development of their children.[8]

The evidence of 'what works' to improve adolescent nutrition is limited. Large-scale, high-quality research on adolescent nutrition programmes in low- and middle-income countries (LMICs) is scarce beyond assessments of single interventions of micronutrient supplementation.[9] Hargreaves and colleagues advocate for a move away from single interventions to adopting multifaceted and multisectoral approaches that consider the interaction between adolescent emotional development, identity formation, and their social environment. [10]

Empowering women and girls for improved health and nutrition is gaining increased attention. The concept of empowerment is reflected in several conceptual frameworks as an important enabling factor for adolescent nutrition. Supporting adolescent agency and resilience is one of five domains included in the Adolescent Well-Being Conceptual Framework.[11] Increased self-efficacy and empowerment mediate the relationship between meaningful adolescent engagement and improved health and wellbeing outcomes in a World Health Organization framework.[12] Another conceptual framework for adolescent growth and nutrition highlights adolescents' growing sense of agency as an influence on the ecosystems shaping their food environment.[1]

There are several reviews available on the quantitative associations between adult women's empowerment and maternal and child nutrition.[13–18] These reviews have produced mixed results on the empowerment–nutrition relationship due to inter-study differences in population characteristics, settings, and conceptualization of empowerment.[14] There is evidence, however, that different domains of empowerment influence maternal and child nutrition differently and that study context influences the relationship.[13,14] Most studies have been conducted in South Asia, but more recent studies have examined the relationship between women's empowerment and maternal and child nutrition in East Africa.[19,20] These studies showed positive associations between domains of women's empowerment and maternal and child nutritional status, including maternal BMI and child weight-for-height and height-for-age.

In contrast, there are relatively few studies that take a similar approach to understanding adolescent girls' particular needs in relation to empowerment and nutrition, and the links between them. One study conducted in the USA found that empowerment (measured by six items assessing adolescents' sense of self-control and of being valued members of their communities) significantly influences adolescents' self-efficacy, perceptions of food choice, healthy eating, attitudes towards physical activity and their overall motivation for health.[21] A limited number of studies incorporate empowerment strategies (such as life skills training and mentorship programs) in LMIC-based adolescent girl nutrition programmes, but the results either showed no impact on nutritional status or are not yet available.[22,23]

Adolescent girls in LMICs face myriad challenges to their ability to exercise agency in their lives, and often experience a shrinking of their autonomy and independence as they transition from childhood to adulthood.[24] In many circumstances, adolescent girls have little say in important life domains, including how long they remain in school, who they marry and when, how many children they will have, and even what and when they eat. The ability to exercise agency varies across life domains. An adolescent girl may have the autonomy to access healthcare but not to choose her future husband. Being empowered in one domain does not necessarily translate into empowerment in others. Understanding which domains are significantly associated with improved nutritional status can help policy makers and practitioners to tailor nutrition interventions to include empowerment strategies that lead to lasting change.

In this study we sought to understand the relationship between adolescent girls' empowerment in different life domains and their nutritional status. We selected an understudied population group for the analysis – single adolescent girls in East Africa – and developed a theoretically-informed model using validated measures of empowerment from Demographic and Health Surveys conducted in five East African countries. This paper describes the model's development, testing, and results, and provides

recommendations for incorporating empowerment strategies into nutrition programmes for this population.

Materials and methods

Conceptualizing empowerment

Our model (Figure 1) is informed by the work of pioneering researchers in the field of women's empowerment, including Kabeer, Alsop, Heinsohn, Sen, and Nussbaum.[25–28] Kabeer defines empowerment as "the process by which those who have been denied the ability to make strategic life choices acquire such an ability."[25] A central component of empowerment is the ability to exercise agency, or "the ability to define one's goals and act upon them."[25] Agency includes the ability to set goals, to believe one can achieve those goals (self-efficacy), and to be motivated by one's own values and preferences. To exercise agency, adolescent girls need access to resources, including income, assets, information, time, and social capital to progress toward their goals.[25] Finally, they need a supportive opportunity structure at home and in the community in the form of adolescent-friendly and gender-sensitive laws, policies, institutional practices, services, and norms that empower them to achieve their goals.[26] Together, agency, resources, and opportunity structure work together to provide adolescent girls with certain capabilities, or ways of 'doing and being' as they choose.[27,28] These capabilities can be present or absent to various degrees in girls' different life domains. In this model, we term these 'empowerment domains.' Our interest in this study was to understand the ways in which girls' capabilities across different empowerment domains lead to improved nutrition outcomes.

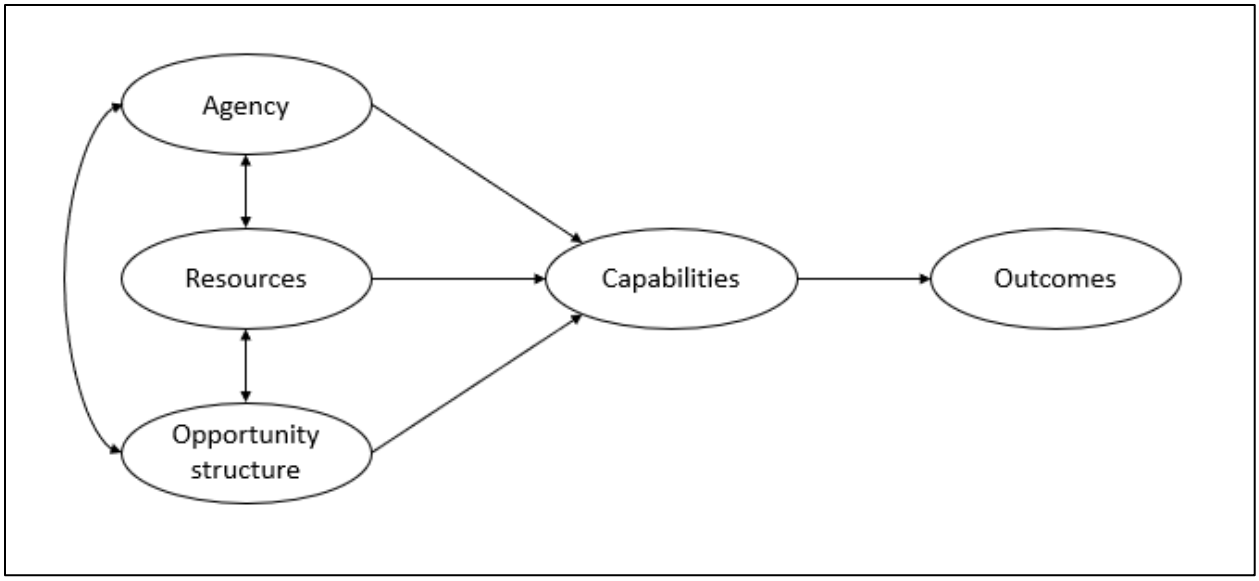


Figure 33. Conceptual model of the process of empowerment.

The empowerment components of agency, resources, and opportunity structure interact to create individuals' capabilities, or ability to "be and do" as they choose. These capabilities vary by empowerment domain. Individuals can use their capabilities to then achieve their intended outcomes, as they have defined them.

Data and sample population

We used cross-sectional Demographic and Health Survey data from five East African countries: Ethiopia (2016), Kenya (2014), Rwanda (2014-15), Tanzania (2015-16), and Uganda (2016). Our study population was single (never married) adolescent girls (15-19 years old) who were sampled for anthropometric measurements and anemia testing.

Model development

Because empowerment is complex and multidimensional, it can be difficult to measure directly. We used exploratory structural equation modelling (ESEM) to capture the complexity of empowerment by using multiple indicators to measure capabilities as latent constructs. Structural equation modelling (SEM) is a group of statistical procedures used for causal inference that tests hypotheses regarding the linear relations among observed variables and latent constructs, making it appropriate to measure a complex and multidimensional construct such as empowerment that cannot be directly observed.[29] The main benefit of ESEM is its allowance for observed variables to cross-load onto more than one factor, thus preventing the inflation of factor correlations and biased estimates.[30] This flexibility is needed for measuring empowerment because much debate remains regarding optimal approaches to its measurement. [31]

There are two components to an ESEM model - the measurement model and the structural model. The measurement model is an exploratory factor analysis (EFA) in a confirmatory factor analysis structure

that confirms the latent structure (factors) of the empowerment indicators. The structural model assesses relationships between the factors and any observed (directly measured) items in the model. We hypothesized a three factor first-order ESEM model describing the relationship between three empowerment domains (factors) and a nutritional outcome while controlling for pre-selected covariates (Figure 2). Separate ESEM models were run for each nutrition outcome of interest.

Outcomes measures

We tested separate models for two primary continuous outcomes measures: adolescent girls' haemoglobin (Hb) (g/dl) (adjusted for altitude and smoking status) and BMI-for-age (BMIZ) (z-score calculated using WHO growth standards for age and sex).[32] Further, we dichotomized the nutrition measures to test models for thinness (BMIZ < -2 SD), overweight and obesity (BMIZ > 1 SD), and anemia (Hb < 12.0 g/dl).

Table 4. Empowerment indicator names, descriptions, and coding by domain.

Empowerment domain	Indicator name	Indicator description	Coding[a]
Access to information	TV	Respondent watches TV less than once per week or more	1 = Yes 0 = No
	Radio	Respondent listens to the radio less than once per week or more	1 = Yes 0 = No
	News	Respondent reads the newspaper or magazines less than once per week or more	1 = Yes 0 = No
	Educ	Respondent's level of completed education	Integer value from 0 to 17
Access to healthcare	Permis	Obtaining permission is not a barrier to access	1 = Yes 0 = No
	Alone	Going alone is not a barrier to access	1 = Yes 0 = No
	Money	Money for treatment is not a barrier to access	1 = Yes 0 = No
	Distance	Distance to the health facility is not a barrier to access	1 = Yes 0 = No
Rejection of justifications for IPV	Burns	A husband is not justified to beat his wife if she burns food	1 = Yes 0 = No or don't know
	Out	A husband is not justified to beat his wife if she goes out alone	1 = Yes 0 = No or don't know

	Neglect	A husband is not justified to beat his wife if she neglects the children	1 = Yes 0 = No or don't know
	Argue	A husband is not justified to beat his wife if she argues with him	1 = Yes 0 = No or don't know
	Refuse	A husband is not justified to beat his wife if she refuses sex	1 = Yes 0 = No or don't know

[a] The indicator is scored as either true (yes) or false (no) for each respondent. In other words, if the statement for indicator *j* is true for the *ith* respondent (*Ri*) then *Rij* = 1. If it is not true, then *Rij* = 0. IPV = Intimate Partner Violence.

Empowerment domains

We selected 13 empowerment indicators to include in our model based on a review of similar studies measuring empowerment using DHS survey data (appendix). The indicators were hypothesized to measure capabilities in three empowerment domains: (1) the ability to access information, (2) the ability to access healthcare, and (3) the ability to reject intimate partner violence (IPV).

Selected indicators had to meet the following criteria: (1) previously used as a measure of empowerment, (2) theoretically justified, (3) have sufficient variability to be meaningful, and (4) collected for our sample population across all country datasets.[33]

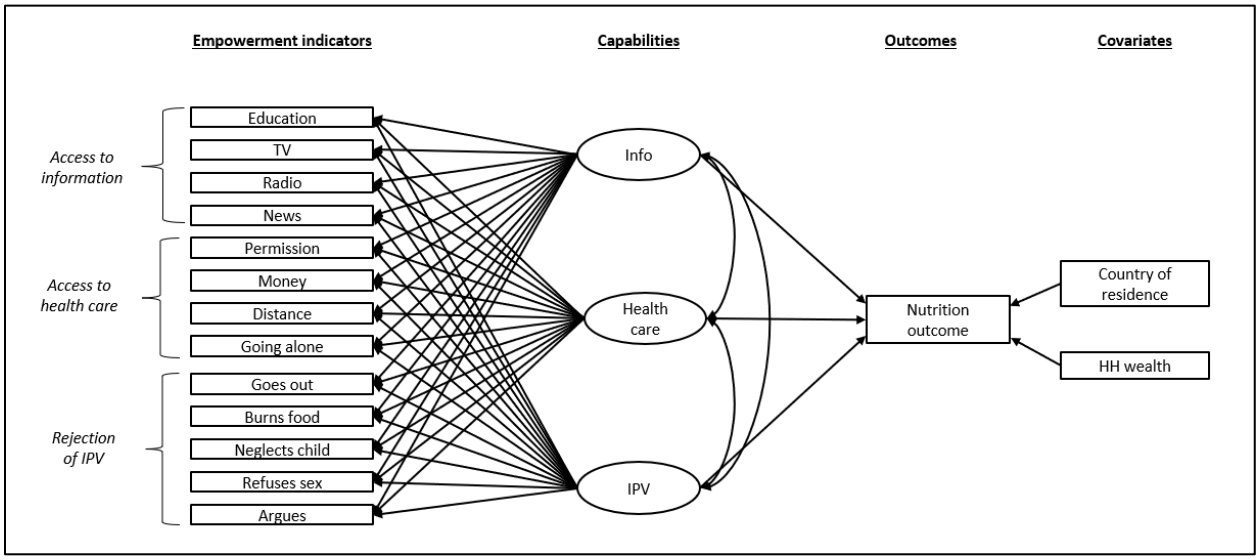


Figure 34. Exploratory structural equation model of the relationship between adolescent girls' capabilities across empowerment domains.

Domains (Access to information, Access to healthcare, Rejection of intimate personal violence) and their nutritional status. Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors

(empowerment domains). Unidirectional arrows represent direct association between exposure on outcome. The lefthand side of the model is an exploratory factor analysis of empowerment indicators to define the underlying factor structure (empowerment domains / capabilities). The righthand side of the model is an adjusted regression analysis of a nutritional outcome on empowerment domains. Both sides of the model are estimated simultaneously. Error terms for estimated variables are omitted to simplify presentation. HH = Household, IPV = Intimate Partner Violence.

Capability #1: Ability to access information

The ability to access information is measured by four indicators – (1) a girl's level of completed education, (2) whether she watches TV, (3) reads the newspaper or magazines, and (4) listens to the radio (Table 1). Access to information is a prerequisite for girls to make informed choices about their nutrition and well-being. Higher education among women and girls is associated with lower fertility rates, delayed marriage and motherhood, and improvements in their long-term health, productivity, and well-being .[34] The longer a girl stays in school, the more likely it is that she will be exposed to empowering life skills programs that can build her confidence, skills, and social capital (such as through peer group learning). We hypothesized that mass media use can provide girls with health-related information through public service announcements and mass media campaigns, expose them to positive role models, and inspire them to set goals beyond the confines of what their day-to-day life may present to them. In contrast, we also acknowledge that mass media may reinforce unhealthy eating behaviours through the promotion of energy-dense, processed and micronutrient-poor foods or unrealistic body image that can lead to eating disorders [35,36].

Capability #2: Ability to access healthcare

This capability is measured by adolescent girls' ability to overcome four barriers to healthcare – (1) lack of money, (2) obtaining permission, (3) distance to the health facility, and (4) not wanting to go alone (Table 1). Adolescent girls can face a multitude of barriers to healthcare that are a product of their lower status in the household and community.[37] As a result, adolescent girls may struggle to access resources to obtain timely health care, such as money for transport or treatment. Going alone to a health facility may be intimidating if they fear mistreatment by health workers, or harassment or abuse while travelling. Time away from the household and their responsibilities may also be discouraged.

Capability #3: Ability to reject intimate partner violence

The ability to reject intimate partner violence (IPV) was measured by whether a girl rejects any or all five proposed justifications for a husband to beat his wife – (1) if she burns food, (2) if she neglects the children, (3) if she argues with him, (4) if she goes out without telling him, and (5) if she refuses sex (Table 1). It is not uncommon for women and girls to internalize unequal gender norms and practices. It

can be difficult for them to counter views generally held in their community, such as those related to the appropriate roles and behaviours attributed to women and men in society. The acceptance of justifications for intimate partner violence illustrates an internalization of women's lower status in society. In contrast, to reject justifications for intimate partner violence can indicate a sense of intrinsic agency and self-worth that is critical to empowerment.

Covariates

We included covariates to control for household wealth and country of residence. We hypothesized that household wealth would influence adolescent girls' nutrition status by directly influencing their access to food, health care, and a healthy environment. Similarly, we expected respondents' country of residence to affect nutritional status due to differing food environments at national and sub-national levels. Household wealth was measured as a continuous composite indicator constructed as part of the DHS. Effect coding was used to create a series of n-1 country indicators, where n is the total number of countries in the model, and the path coefficient value was the country value of a given measure compared to the unweighted grand mean (UGM) of all countries in the model.

Model estimation and evaluation

Model estimation and evaluation was conducted in Mplus 8.1. The models were built stepwise, beginning with the measurement model. We tested two measurement models using the Mean and Variance-Adjusted Weighted Least Squares (WLSMV) estimator. The first was a confirmatory factor analysis of the three first-order factors whereby empowerment indicators were restricted to only load onto their a priori theorized factors and cross-loadings were restricted to zero. The second model was an ESEM whereby empowerment indicators were again modelled to load onto their theorized factor, however, in this model cross-loadings onto other factors were permitted. An oblique targeted rotation was used that allowed the factors to be correlated. We hypothesized that the ESEM model would provide a better fit for the data given that restricting cross-loadings to zero is considered an overly restrictive modelling approach that has been shown to produce biased factor correlations and loadings.[30] Both models accounted for the DHS complex survey design by incorporating variables for sampling weights, stratification, and clustering. Model fit was assessed against the criteria set out by van Zyl and ten Klooster.[38]

Measurement quality of the competing models was assessed by examining (1) the standardized parameter estimates (factor loadings) with a cut-off of > 0.400 on a priori factor and less than 0.300 on other factors, (2) item uniqueness (residual error variances >0.10 and <0.90), and (3) overall R^2 for each item.[38] The model with the superior model fit and measurement quality, along with lower factor correlations (indicating better discriminate validity) was retained.

Once the best fitting measurement model was obtained, the structural model was built by first adding the nutrition outcome and capturing the crude estimates of association between the outcome and the empowerment domains, followed by a fully adjusted model that included the model covariates. Model fit was assessed using the same indices as the measurement model and according to standard model fit indices cut-offs.[39] Modification indices were then inspected to ascertain whether the addition of paths to the model would improve model fit. Any paths that were considered for addition needed to be theoretically justified. Additional paths were added one at a time beginning with the path that would lead to the greatest reduction in the chi-square value (and greatest improvement in model fit). Once all theoretically justified paths were added, the model was finalized. We report the standardized path coefficients (ß) from the structural model which represent the relative magnitude of association between the outcome and empowerment domains. Statistical significance was determined at the $\alpha > 0.05$ level.

Subgroup analyses

We conducted two prespecified subgroup analyses to assess differences between (1) respondents living in urban and rural settings and (2) respondents who reported attending school in the last year and those who did not. Geographic location can affect both nutritional status and level of empowerment.[40,41] Similarly, schools are important delivery platforms for nutrition and empowerment.[9,42]

Results

Sample population

The total sample included 9,849 respondents. Their mean age was 16.7 years and mean level of completed education was almost 7 years. Most respondents reported attending school in the last year (63.5%) and one-third lived in an urban setting. Few respondents were either pregnant (1.2%) or breastfeeding (3.0%). Anemia affected just over 30% of the sample population. The prevalence of thinness was low (3.9%) while more than 12% of girls were overweight or obese. Half of respondents were from a household above the median wealth quintile. These statistics varied considerably by country (Table 2).

Most respondents (69.3%) reported listening to the radio while half (50%) watched TV and fewer than 40% reported reading a newspaper or magazine (Table 2). Ethiopian respondents reported the lowest levels of mass media use, with significantly fewer Ethiopian girls reporting listening to the radio or reading a newspaper or magazine compared to their regional peers. Most respondents were able to overcome common barriers to healthcare access; obtaining money for treatment was the most common challenge they faced. Kenyan respondents reported the greatest ability to overcome all healthcare barriers.

Across all countries, more than half of respondents rejected all justifications for IPV with the highest percentage saying burning food was not a justification for a husband to beat his wife. Child neglect received the most support as a justification for IPV (40.8%).

Table 5. Regional and country-specific descriptive statistics of the study population.

Variable	Regional (n = 9849) % (n)	Ethiopia (n = 2710) % (n)	Tanzania (n= 2248) % (n)	Kenya (n = 2473) % (n)	Uganda (n = 1082) % (n)	Rwanda (n = 1336) % (n)
Mean age (SD)	16.7 (1.4)	16.7 (1.3)	16.7 (1.4)	16.7 (1.4)	16.6 (1.3)	16.8 (1.4)
Mean level of completed education (years), (SD)	6.9 (3.0)	5.9 (3.4)	7.5 (2.4)	7.9 (2.7)	6.6 (2.9)	5.9 (2.4)
In school in the last year	63.5 (6240)	65.0 (1761)	50.2 (1128)	78.3 (751)	66.6 (721)	53.3 704)
Living in an urban setting	33.5 (3303)	40.7 (1104)	36.2 (814)	30.4 (1926)	24.3 (263)	27.8 (371)
Household wealth quintiles						
Poorest	17.1 (1684)	18.0 (488)	11.1 (249)	21.0 (519)	20.2 (219)	15.6 (209)
Poorer	15.7 (1545)	10.7 (289)	13.1 (294)	22.6(560)	17.7 (190)	15.9 (212)
Middle	17.4 (1718)	13.1 (354)	16.6 (373)	22.7 (562)	19.0 (206)	16.7 (223)
Richer	19.4 (1910)	14.7 (399)	25.6 (576)	18.3 (452)	19.6 (212)	20.3 (271)
Richest	30.4 (2992)	43.5 (1180)	33.6 (756)	15.4 (380)	32.6 (255)	31.5 (421)
Currently pregnant	1.2 (121)	0.1 (3)	2.1 (48)	1.4 (35)	1.9 (20)	1.1 (15)
Currently breastfeeding	3.0 (291)	0.3 (9)	4.2 (95)	4.5 (111)	4.1 (44)	2.4 (32)
Mean Hb (g/dl), (SD)	12.6 (1.6)	13.0 (1.7)	12.0 (1.6)	NA	12.5 (1.6)	13.0 (1.4)
Anemia	30.3 (2143)	21.7 (530)	46.5 (1033)	NA	31.6 (334)	18.5 (246)
Moderate to severe anemia	5.8 (410)	4.8 (118)	9.3 (207)	NA	5.2 (55)	2.3 (30)
Mean BMI (kg/m^2), (SD)	20.9 (3.3)	19.9 (2.8)	21.3 (3.5)	21.0 (3.8)	21.2 (2.8)	21.9 (2.9)
Thin	3.9 (367)	7.6 (192)	2.4 (53)	3.8 (89)	1.5 (16)	1.3 (17)
Overweight or obese	12.2 (1145)	6.5 (164)	14.8 (324)	12.6 (297)	12.0 (125)	17.9 (235)
Watches TV	49.8 (4800)	44.5(1205)	65.0 (1462)	45.3 (1120)	33.1 (358)	56.6 (755)
Reads the newspaper	39.4 (3878)	27.1 (734)	53.1 (1193)	47.6 (1176)	25.2(273)	37.6 (502)
Listens to the radio	69.3 (6825)	39.6 (1074)	80.2 (1803)	81.0 (2002)	70.7(765)	88.6 (1181)
Permission is not a barrier to HC	85.4 (8411)	72.3 (1958)	85.0 (1911)	92.0 (2274)	90.7 (981)	96.3 (1287)
Money is not a barrier to HC	58.4 (5746)	54.2 (1469)	57.8 (1299)	64.4 (1592)	56.6 (612)	57.9 (774)
Distance is not a barrier to HC	70.0 (6892)	61.1 (1656)	66.1 (1486)	77.8 (1924)	65.5 (709)	83.6 (1117)
Going alone is not a barrier to HC	74.1 (7297)	63.8 (1738)	72.1 (1620)	84.4 (2080)	75.3 (815)	78.9 (1054)
Going out alone is not a justification for IPV	67.2 (6622)	66.5 (1803)	58.3 (1310)	73.5 (1818)	64.7 (700)	74.2 (991)
Burning food is not a justification for IPV	80.5 (7929)	70.7 (1918)	79.1 (1778)	88.6 (2190)	79.2(857)	89.0 (1186)

Neglecting the children is not a justification for IPV	59.2 (5830)	61.6 (1668)	52.4 (1177)	60.8 (1503)	55.0 (595)	66.4 (887)
Refusing sex is not a justification for IPV	73.8 (7272)	73.0 (1979)	66.4 (1492)	80.1 (1981)	76.9 (832)	74.0 (988)
Arguing is not a justification for IPV	67.8 (6675)	67.2 (1820)	56.6 (1272)	74.9 (1852)	65.1 (704)	77.0 (1027)

BMI = Body Mass Index, Hb = Haemoglobin, HC = Healthcare, IPV = Intimate Partner Violence, NA = Not Available, SD = Standard Deviation.

Measurement model

The ESEM measurement model produced a better fit compared to its CFA counterpart and was selected as our final model (appendix). The model's measurement quality was high, with standardized parameter estimates exceeding 0.400 and cross loadings below the pre-specified threshold (appendix). Item residual variances ranged from 0.187 to 0.524 and factor correlations were low enough (range: 0.301 to 0.433) to suggest sufficient discriminant validity. A three-factor model was confirmed with all 13 items meeting our pre-specified measurement cut-offs.

Structural model

The standardized results of the structural models are presented below and in Table 3, Figure 3, and Figure 4. The unstandardized results are available in the appendix.

Haemoglobin model

Of the three empowerment domains, only the ability to access information had a direct and statistically significant association with increased haemoglobin (ß = 0.070, 95% CI = 0.006, 0.134). Expressed in original units, each one unit increase in the ability to access information was associated with a 0.122 increase in Hb (appendix). Neither the ability to access healthcare nor the ability to reject IPV had a statistically significant association with haemoglobin (Table 3). Further, the ability to access information was the only empowerment domain significantly associated with the odds of being anemic (OR = 0.923, 95% CI = 0.860, 0.992) (appendix).

Hb model by geographic location

The magnitude of the association between the ability to access information and haemoglobin was higher for girls living in a rural setting (ß = 0.117, 95% CI = 0.049, 0.185) and was no longer statistically significant for girls living in urban areas (ß = -0.066, 95% CI = -0.148, 0.015). In contrast, the ability to access healthcare was directly associated with higher haemoglobins levels among girls living in an urban setting (ß = 0.117, 95% CI = 0.049, 0.185) but remained non-significant for girls in rural areas (ß = -0.007, 95% CI = -0.056, 0.043). The ability to reject IPV was not significantly associated with haemoglobin for urban or rural respondents (Table 3).

Hb model by in-school status

No empowerment domains had a statistically significant association with haemoglobin when the respondents were stratified by in-school status.

BMIZ model

The ability to access information was significantly associated with increased BMIZ (ß = 0.094, 95% CI = 0.045, 0.143) and increased odds of being overweight or obese (OR = 1.088, 95% CI = 1.014, 1.166) (appendix). Expressed in original units, a one unit increase in the ability to access information was associated with a 0.087 increase in BMIZ (appendix). The ability to access healthcare and the ability to reject IPV were not significantly associated with BMIZ (Table 3). No empowerment domains were significantly associated with thinness (appendix).

BMIZ model by geographic location

The association between the ability to access information and BMIZ increased in magnitude for girls living in a rural setting (ß = 0.114, 95% CI = 0.060, 0.169) but became non-significant for girls living in urban areas (ß = -0.022, 95% CI = -0.082, 0.039). The ability to access healthcare was not significantly associated with BMIZ for girls living in urban or rural areas (Table 3). The ability to reject IPV had a small but significantly association with increased BMIZ for girls living in rural areas (ß = 0.040, 95% CI =0.003, 0.076) but not for girls in urban areas (ß = 0.022, 95% CI = -0.069, 0.074).

BMIZ model by in-school status

The association between the ability to access information and BMIZ increased in magnitude for girls who reported attending school in the last year (ß = 0.212, 95% CI = 0.151, 0.272). This relationship was non-significant for girls who did not attend school in the previous year (ß = 0.021, 95% CI = -0.054, 0.097). The ability to reject IPV was significantly associated with increased BMIZ for girls who attended school in the last year only (ß = 0.043, 95% CI = 0.001, 0.086) (Table 3).

The influence of country of residence

Our original model only included paths from country of residence to nutritional status; however, a review of the modification indices suggested the addition of paths from country of residence to each empowerment domain to improve model fit. After considering their theoretical justification, we included these paths in the final models.

Country of residence was significantly associated with adolescent girls' nutritional status and their level of empowerment across all domains, but the association varied by country. Ethiopian respondents had lower empowerment domain scores across all capabilities compared to the UGM, while Kenyan and Rwandan respondents trended higher on all domains (Figures 3 and 4). Tanzanians score lower than the UGM for access to information and rejecting IPV, but higher for access to healthcare. Ugandans scored

lower on access to information and higher on access to healthcare; their score on rejecting IPV was close to the UGM in both models.

The influence of household wealth

A review of modification indices also suggested additional paths from household wealth to each empowerment domain, and these were included in the final models.

Household wealth was significantly associated with increased BMIZ (ß = 0.160, 95% CI = 0.126, 0.194), increased ability to access information (ß = 0.512, 95% CI = 0.488, 0.536), increased ability to access healthcare (ß = 0.238, 95% CI = 0.191, 0.286) and increased ability to reject IPV (ß = 0.215, 95% CI = 0.174, 0.256).

Like the BMIZ model, household wealth was also directly and positively associated with all empowerment domains in the Hb model (appendix). However, household wealth was not significantly associated with respondents' haemoglobin levels (ß = 0.007, 95% CI = -0.033, 0.047).

Table 6. Standardized path coefficients and 95% confidence intervals for haemoglobin and BMIZ by empowerment domain for main models and sub-groups.

Model	N	Standardized path coefficients (95% CI)		
		Access to information	Access to healthcare	Rejects IPV
Haemoglobin				
Main model	7376	**0.071 (0.011, 0.130)**	0.027 (-0.014, 0.068)	0.018 (-0.017, 0.053)
Subgroup analyses				
Lives in an urban setting	2552	-0.066 (-0.148, 0.015)	**0.074 (0.008, 0.140)**	0.034 (-0.032, 0.099)
Lives in a rural setting	4824	**0.112 (0.047, 0.178)**	-0.007 (-0.056, 0.043)	0.010 (-0.032, 0.052)
In school in the last year	4314	0.051 (-0.041, 0.143)	0.025 (-0.028, 0.078)	0.021 (-0.028, 0.070)
Not in school in the last year	3046	0.085 (-0.004, 0.174)	0.026 (-0.039, 0.091)	0.008 (-0.045, 0.060)
BMIZ				
Main model	9728	**0.089 (0.044, 0.134)**	-0.007 (-0.044, 0.030)	0.030 (-0.002, 0.063)
Subgroup analyses				
Lives in an urban setting	3266	-0.022 (-0.082, 0.039)	0.025 (-0.045, 0.095)	0.002 (-0.069, 0.074)
Lives in a rural setting	6462	**0.114**	-0.023	**0.040**

		(0.060, 0.169)	(-0.066, 0.020)	**(0.003, 0.076)**
In school in the last year	6205	**0.212 (0.151, 0.272)**	0.005 (-0.040, 0.050)	**0.043 (0.001, 0.086)**
Not in school in the last year	3496	0.021 (-0.054, 0.097)	-0.028 (-0.083, 0.027)	0.046 (-0.003, 0.095)

BMIZ = BMI-for-age z-score, CI = Confidence Interval, IPV = Intimate Partner Violence.

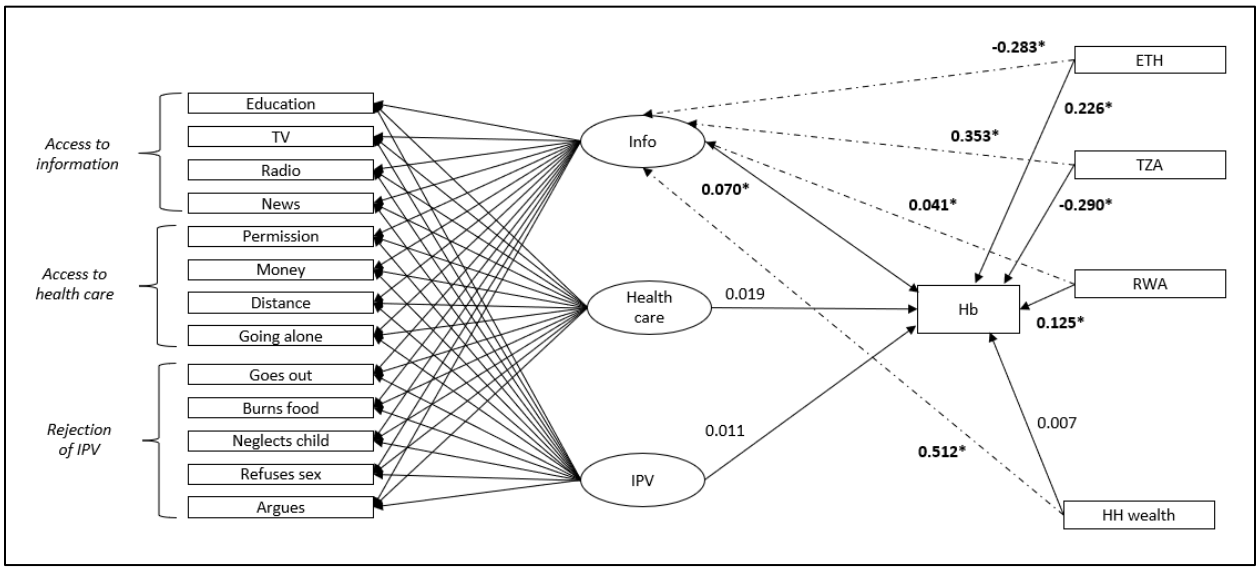


Figure 35. Exploratory structural equation model of the relationship between adolescent girls' capabilities across empowerment domains (Access to information, Access to healthcare, Rejection of intimate personal violence) and haemoglobin.

Values are standardized path coefficients. Bolded values are significant at the 0.05 level. Only statistically significant paths and values are presented. Paths indicated by a dotted line were added to the model following a review of modification indices to improve model fit. Similar paths from household wealth and countries of residence to the remaining empowerment domains were statistically significant but are not shown to simplify figure interpretation. ETH = Ethiopia, Hb = Haemoglobin, HH = Household, IPV = Intimate Partner Violence, RWA = Rwanda, TZA = Tanzania.

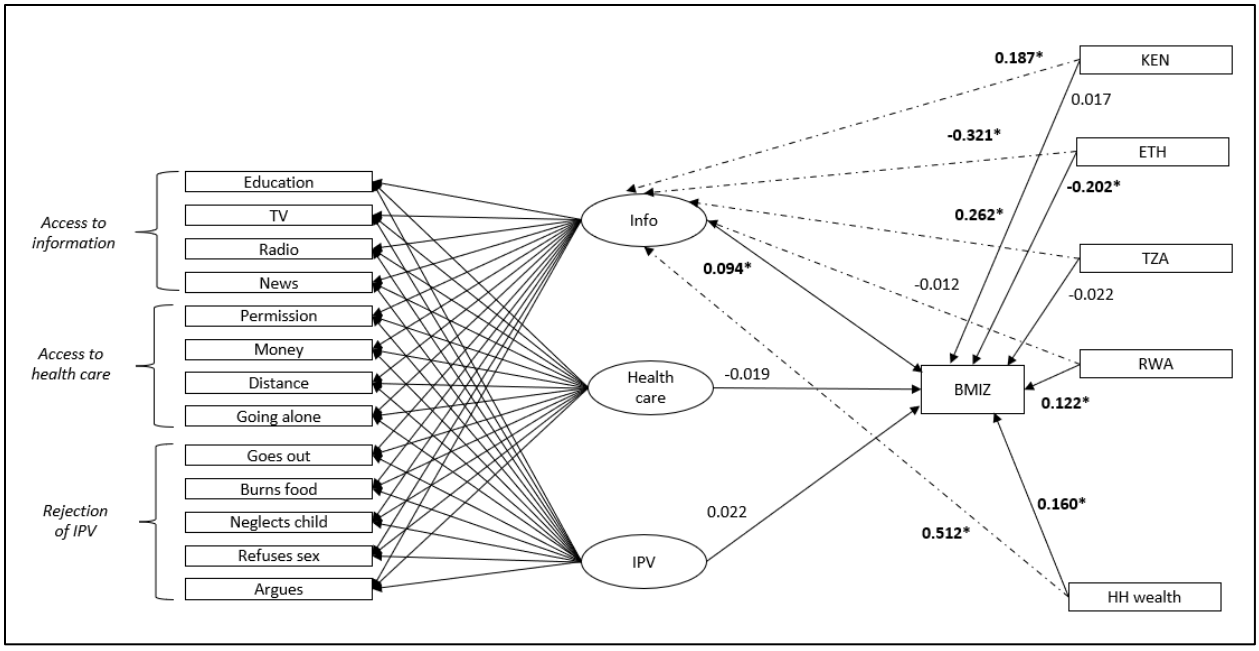


Figure 36. Exploratory structural equation model of the relationship between adolescent girls' capabilities across empowerment domains (Access to information, Access to healthcare, Rejection of intimate personal violence) and BMIZ.

Values are standardized path coefficients. Bolded values are significant at the 0.05 level. Only statistically significant paths and values are presented. Paths indicated by a dotted line were added to the model following a review of modification indices to improve model fit. Similar paths from household wealth and countries of residence to the remaining empowerment domains were statistically significant but are not shown to simplify figure interpretation. BMIZ = BMI-for-age z-score, ETH = Ethiopia, HH = Household, IPV = Intimate Partner Violence, KEN = Kenya, RWA = Rwanda, TZA = Tanzania.

Discussion

Our models demonstrate that there is a relationship between single adolescent girls' empowerment and their nutritional status in East Africa, and that this relationship varies by adolescent girls' individual characteristics and context. This study helps to fill an important gap in our understanding of the role that empowerment plays in the nutritional status of adolescent girls.

Out of the three empowerment domains examined in our study, we found that the ability to access information, measured by level of education and mass media use, was significantly associated with four out of five nutrition outcomes of interest. The ability to access information was significantly associated with increased haemoglobin and BMIZ after controlling for household wealth and country of residence. The same domain was significantly associated with reduced odds of being anemic and increased odds of being overweight or obese. No significant relationship between empowerment and thinness was identified, however, only 367 (3.9%) of sample respondents were categorized as thin in our sample.

When examining subgroup differences, the relationship between empowerment and nutrition was more complex. Living in a rural setting increased the magnitude of the positive relationship between the ability to access information and haemoglobin and BMIZ, while the same relationships were non-significant for girls living in an urban setting. Instead, the ability to access healthcare by overcoming common gender-related barriers to health care, such as permission and cost, was positively associated with haemoglobin levels for girls living in an urban setting, but non-significant for BMIZ. Further, the ability to reject IPV had a small but statistically significant association with increased BMIZ for rural residents and respondents who attended school in the last year. However, the lower bound of the 95% confidence intervals closely approached zero in both models, which may indicate a spurious rather than substantive association. The relationship between the ability to reject IPV and nutritional status was non-significant for all other groups.

For girls living in rural settings, the ability to access information through education and mass media may be their most direct avenue to accessing nutrition education and services. Schools are a primary delivery platform for nutrition-related interventions for adolescent girls, including nutrition education, micronutrient supplementation, and deworming.[43,44] The importance of the ability to access healthcare for urban-based respondents may reflect the fact that there are fewer barriers to healthcare in urban settings, and this capability is easier for them to achieve.[45] With increased access to healthcare, illness and disease most often associated with haemoglobin deficiencies, such as malaria or soil transmitted helminth infection, may be more easily avoided or treated, and access to iron supplementation may be higher.

East Africa faces a double burden of malnutrition characterized by persistent rates of undernutrition and micronutrient deficiencies and increasing rates of overweight and obesity.[46] Our results show that the ability to access information can lead to increased BMIZ, including increased odds of being overweight or obese. This relationship may be due to increased exposure to mass media advertising of energy-dense, processed and micronutrient-poor foods. With increased agency, adolescents may opt for these foods, depending on their food environment and sociocultural context.[47] Interventions that seek to improve adolescent girls' access to information as an empowerment strategy should also consider the potential negative influences of media on diet and body image and seek to empower them with a complete portrayal of what constitutes healthy choices. Social media can be leveraged to encourage healthier choices and meaningfully engage adolescents in the change process.[10]

Our findings agree with existing literature that the empowerment process is highly dependent on an individual's characteristics and context, and that interventions to address adolescent girls' empowerment and nutrition need to consider their specific characteristics and circumstances that contribute to their

disempowerment and increase their vulnerability to poor health, such as geographic location, socioeconomic status, and level of education. For example, a mixed-methods study in Ethiopia found that gender discrimination intersects with other social identities (age, disability) and structural factors (rurality, service availability) to affect their nutrition and food insecurity.[48] Another study showed that favourable social norms related to education, marriage and nutrition were positively associated with adolescent girls' agency.[49] Addressing community structures and norms is considered an integral component of empowering girls to prevent adolescent pregnancy.[50] Investments in adolescent capabilities must address not only individual agency but structural inequalities to support young people's well-being.[51]

Applying an intersectional lens to understanding adolescent girls' marginalization can help to elucidate how individual identities combine with structural challenges to contribute to disempowerment and poor nutrition.[51] The concept of intersectionality examines how a person's social identity, such as their age, race, sexual orientation, etc., and systems of power "intersect" and shape their life circumstances. Interventions to empower adolescent girls for improved nutrition should consider their intersecting identities and develop strategies that respond to their particular circumstances.

Our study has several strengths. First, the development of our model was informed by existing empowerment theory and evidence that emphasises the multidimensional nature of the process of empowerment. Second, we used robust statistical methods, ESEM, that could accommodate the challenge of measuring a concept that cannot be directly observed. Third, we used previously validated measures of empowerment (for example, see [20,52,53]) from nationally-representative, standardized surveys. We recognize two limitations to our study. First, the use of cross-sectional data precludes drawing conclusions about the causal relationship between empowerment and nutrition. Second, our study sample did not include measures for other empowerment domains, such as economic empowerment. Strategies to economically empower women for improved nutrition, such as through conditional cash transfers or microfinance programs, are among the most common intervention strategies, though with mixed results.[18,54] There is some evidence of the critical importance of economic empowerment in positive reproductive health outcomes.[55] A similar exploration of the role that economic empowerment and other empowerment domains can play in adolescent girls' nutrition is needed.

Engaging adolescents through participatory research and program design is one way to support nutrition programs to adopt relevant empowerment strategies that meet their needs and priorities. Adolescents should be viewed as change agents with the power to influence their communities in positive ways and should be included as co-creators of programmes that seek to serve their interests. Meaningful participation that goes beyond adolescents being physically present to supporting them to safely express

themselves and contribute to decision-making is an empowering approach and should be prioritized in adolescent nutrition programming.

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Appendix

List of selected empowerment studies using DHS data

Asaolu, I. O., Alaofè, H., Gunn, J. K. L., Adu, A. K., Monroy, A. J., Ehiri, J. E., Hayden, M. H., & Ernst, K. C. (2018). Measuring Women's Empowerment in Sub-Saharan Africa: Exploratory and Confirmatory Factor Analyses of the Demographic and Health Surveys. Frontiers in Psychology, 9. https://doi.org/10.3389/fpsyg.2018.00994

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Ewerling, F., Lynch, J. W., Victora, C. G., van Eerdewijk, A., Tyszler, M., & Barros, A. J. D. (2017). The SWPER index for women's empowerment in Africa: development and validation of an index based on survey data. The Lancet Global Health, 5(9), e916–e923. https://doi.org/10.1016/S2214-109X(17)30292-9

Ewerling, F., Raj, A., Victora, C. G., Hellwig, F., Coll, C. V. N., & Barros, A. J. D. (2020). SWPER Global: A survey-based women's empowerment index expanded from Africa to all low- and middle-income countries. JOURNAL OF GLOBAL HEALTH, 10(2). https://doi.org/10.7189/jogh.10.020434

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Jones, R. E., Haardörfer, R., Ramakrishnan, U., Yount, K. M., Miedema, S. S., Roach, T. D., & Girard, A. W. (2020). Intrinsic and instrumental agency associated with nutritional status of East African women. Social Science & Medicine, 247, 112803. https://doi.org/10.1016/j.socscimed.2020.112803

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Kabir, A., Rashid, M. M., Hossain, K., Khan, A., Sikder, S. S., & Gidding, H. F. (2020). Women's empowerment is associated with maternal nutrition and low birth weight: evidence from Bangladesh Demographic and Health Survey. BMC Women's Health, 20(93).

Kishor, S., & Subaiya, L. (2008). Understanding Women's Empowerment: A Comparative Analysis of Demographic and Health Surveys (DHS) Data. In DHS Comparative Reports No. 20.

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Na, M., Jennings, L., Talegawkar, S. A., & Ahmed, S. (2015). Association between women's empowerment and infant and child feeding practices in sub-Saharan Africa: an analysis of Demographic and Health Surveys. Public Health Nutrition, 18(17), 3155–3165. https://doi.org/10.1017/S1368980015002621

Pratley, P., & Sandberg, J. F. (2018). Refining the Conceptualization and Measurement of Women's Empowerment in Sub-Saharan Africa Using Data from the 2013 Nigerian Demographic and Health Survey. Social Indicators Research, 140(2), 777–793. https://doi.org/10.1007/s11205-017-1811-1

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Shimamoto, K., & Gipson, J. D. (2019). Investigating pathways linking women's status and empowerment to skilled attendance at birth in Tanzania: A structural equation modeling approach. PLOS ONE, 14(2), e0212038. https://doi.org/10.1371/journal.pone.0212038

Yaya, S., Odusina, E. K., Uthman, O. A., & Bishwajit, G. (2020). What does women's empowerment have to do with malnutrition in Sub-Saharan Africa? Evidence from demographic and health surveys from 30 countries. Global Health Research and Policy, 5(1), 1. https://doi.org/10.1186/s41256-019-0129-8

Table S1. SEM model fit statistics and assessment criteria.

Fit indices	Cut-off criterion	Sensitive to N	Penalty for model complexity
Chi-square	· Lowest comparative value between models · Non-significant Chi-Square (p >0.01) · Significant difference in Chi-square between models · For model comparison: retain model with lowest Chi-Square	Yes	No
RMSEA	· 0.06-0.08 (marginally acceptable, 0.01-0.05 (excellent) · Non-significant (p>0.05) · 90%CI range does not include zero · 90%CI range should not overlap between models · For model comparison: Retain model where [change]RMSEA <= 0.015	No	Yes
SRMR	· 0.06-0.08 (marginally acceptable), 0.01-0.05 (excellent) · For model comparison: Retain model with [change]SRMR <=0.015	Yes	No
CFI	· 0.90-0.95 (marginally acceptable fit), 0.96 –0.99 (excellent) · For model comparison: Retain model with highest CFI value ([change]CFI > 0.01)	No	No
TLI	· 0.90-0.95 (marginally acceptable fit), 0.96-0.99 (excellent) · For model comparison: Retain model with highest CFI value ([change]CFI > 0.01)	No	Yes

Source: van Zyl, L. E., & ten Klooster, P. M. (2022). Exploratory Structural Equation Modeling: Practical Guidelines and Tutorial With a Convenient Online Tool for Mplus. *Frontiers in Psychiatry*, *12*, 795672. https://doi.org/10.3389/fpsyt.2021.795672

Table S2. Comparison of model fit for CFA and ESEM models.

Model	X^2 (df)	RMSEA (90% CI)	CFI	TLI	SRMR
1. CFA	629.743 (62)	0.030 (0.028, 0.033)	0.976	0.970	0.044
2. ESEM	441.370 (42)	0.031 (0.028, 0.034)	0.983	0.969	0.024
Difference (M1-M2)	188.373	-0.01	-0.007	0.001	0.020

Table S3. Standardized parameter estimates for measurement model.

Empowerment indicator	Access to information	Access to healthcare	Views on IPV
Level of completed education	**0.550**	0.018	0.113
Watches TV	**0.664**	0.078	-0.013
Reads the newspaper or magazines	**0.783**	-0.112	-0.026
Listens to the radio	**0.657**	0.082	-0.017
Permission is not a barrier to HC	-0.002	**0.816**	0.038
Money is not a barrier to HC	0.054	**0.734**	-0.029
Distance is not a barrier to HC	0.008	**0.831**	0.012
Going alone is not a barrier to HC	-0.037	**0.798**	-0.016
Going out alone is not a justification for IPV	-0.051	0.032	**0.881**
Burning food is not a justification for IPV	0.166	0.017	**0.777**
Neglecting the children is not a justification for IPV	-0.135	-0.002	**0.917**
Refusing sex is not a justification for IPV	0.073	-0.053	**0.822**
Arguing is not a justification for IPV	-0.015	0.007	**0.905**

HC = Healthcare.
IPV = Intimate Partner Violence.
Bolded = significant at 0.05 level.

Table S4. Odds ratio for overweight/obesity, thinness, anemia.

Model	N	Standardized path coefficients (95% CI)		
		Access to information	Access to healthcare	Rejects IPV
Anemia	7376	**0.923 (0.860, 0.992)**	0.958 (0.907, 1.011)	0.969 (0.924, 1.015)
Overweight/obesity	9728	**1.088 (1.014, 1.166)**	0.957 (0.899, 1.018)	1.035 (0.983, 1.091)
Thinness	9728	0.935 (0.836, 1.047)	1.022 (0.944, 1.106)	0.982 (0.914, 1.055)

Table S5. Unstandardized parameter estimates of path coefficients and 95% confidence intervals for haemoglobin and BMIZ by empowerment domain for main models and sub-groups.

Model	N	Unstandardized path coefficients (95% CI)		
		Access to information	Access to healthcare	Rejects IPV
Haemoglobin				
Main model	7376	**0.122 (0.020, 0.224)**	0.036 (-0.020, 0.092)	0.028 (-0.027, 0.083)
Subgroup analyses				
Lives in an urban setting	2552	-0.141 (-0.317, 0.035)	**0.103 (0.011, 0.196)**	0.052 (-0.049, 0.154)
Lives in a rural setting	4824	**0.112 (0.047, 0.178)**	-0.007 (-0.056, 0.043)	0.010 (-0.032, 0.052)
In school in the last year	4314	0.085 (-0.067, 0.238)	0.036 (-0.039, 0.111)	0.027 (-0.036, 0.090)
Not in school in the last year	3046	0.136 (-0.005, 0.227)	0.037 (-0.057, 0.131)	0.012 (-0.073, 0.097)
BMIZ				
Main model	9728	**0.087 (0.042, 0.131)**	-0.006 (-0.038, 0.026)	0.029 (-0.002, 0.061)
Subgroup analyses				
Lives in an urban setting	3266	-0.024 (-0.090, 0.042)	0.021 (-0.038, 0.080)	0.002 (-0.063, 0.068)
Lives in a rural setting	6462	**0.105 (0.054, 0.157)**	-0.066 (-0.190, 0.058)	**0.027 (0.002,0.052)**
In school in the last year	6205	**0.229 (0.162, 0.296)**	0.005 (-0.036, 0.045)	**0.034 (0.001, 0.068)**
Not in school in the last year	3496	0.017 (-0.043, 0.076)	-0.024 (-0.071, 0.023)	0.042 (-0.002, 0.086)

CHAPTER 6: Discussion and conclusion

Chapter overview

This thesis explored the relationship between adolescent girls' empowerment and their nutritional status in LMICs. Specifically, the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs were assessed via a mixed-methods systematic review (Chapter 3), and the statistical associations between dimensions of adolescent girls' empowerment and their nutritional status were assessed using theoretically informed exploratory structural equation models (ESEM) for married adolescent girls (Chapter 4) and single (never-married) adolescent girls in East Africa (Chapter 5).

This final chapter serves as an overall discussion and conclusion for the thesis. Each manuscript contained in Chapters 3–5 includes a discussion section specific to that study.

This chapter is intended to:

- Summarize the thesis rationale, objectives, and main findings.
- Consider the implications of the thesis findings for Canadian policy and practice.
- Highlight the novelty of the thesis and describe its strengths and weaknesses.
- Provide suggestions for future research in this area.

Summary of thesis rationale and objectives

Proper nutritional support during adolescence is critical for optimal physiological, neurological, emotional, and immunological development, with consequences for current and future generations. Persistent rates of undernutrition, including thinness and micronutrient deficiencies, and rising rates of overweight and obesity among adolescents in LMICs require the global health community to adopt a comprehensive approach to adolescent health and nutrition that meets adolescents' immediate needs for nutritional support as well as address the underlying drivers that contribute to malnutrition generally.

Global strategies and frameworks addressing adolescent health, nutrition, and well-being consistently highlight the importance of empowering women and girls. However, empowerment is a complex and multidimensional construct that is challenging to define, operationalize, and measure. While many recent studies have focused on understanding the relationship between empowerment and maternal and child nutrition, a specific focus on adolescent girls has been lacking. Consequently, this thesis developed and applied a theoretically informed model of the empowerment–nutrition relationship for adolescent girls to:

3. Assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs, and
4. Identify the dimensions of empowerment significantly associated with adolescent girls' nutritional status in LMICs.

Findings and implications

Summary of findings

The manuscripts included in this thesis are distributed across three chapters (Chapters 3–5). The key findings from each chapter in relation to the thesis objectives are summarized in Table 1. Following the table, the implications of the thesis findings for Canadian policy and practice are discussed.

Table 1. Summary of key thesis findings.

Research objective	Chapter	Key findings
To assess the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status in LMICs.	Chapter 3 *Mixed methods systematic review*	• There is currently limited/no evidence that empowerment-based nutrition interventions contribute to improved nutritional status among adolescent girls in LMICs, but the evidence base is scarce, heterogenous, and largely lacking in methodological quality. • The existing evidence base is largely limited to interventions to prevent or treat obesity among adolescent girls in middle-income countries. • Heterogeneity in intervention design, along with a lack of standardized measures for empowerment, dietary intake, and nutrition behaviours, make it difficult to synthesize results across studies. • Many studies lack sufficient methodological quality, lowering the confidence that the true intervention effect is represented by current evidence. • More research is needed into the implementation and contextual factors that contribute to intervention success. • Adolescent nutrition researchers need to sex-disaggregate their results and consider the sex and gender implications of their research. • Some important nutrition and empowerment outcomes along the causal chain are not currently measured in studies.
To identify the dimensions of empowerment significantly	Chapter 4	• Married adolescent girls' ability to access information through education and mass media use is positively associated with their BMI-for-age.

Research objective	Chapter	Key findings
associated with adolescent girls' nutritional status in LMICs.	*Exploratory structural equation modelling*	• Married adolescent girls' ability to own assets (i.e., owning a house or land either alone or jointly) is positively associated with haemoglobin and reduced odds of being moderately to severely anemic. • Married adolescent girls' level of empowerment is directly associated with their level of household wealth and the country they live in. • Greater autonomy may contribute to increased consumption of unhealthy foods that can contribute to overweight and obesity. • Strategies to empower married adolescent girls should be tailored to their specific circumstances. • There is an urgent need for better data on adolescent empowerment and health, including increased research into age-, sex- and gender-appropriate empowerment measures and longitudinal data to assess causality.
	Chapter 5 *Exploratory structural equation modelling*	• Improving single adolescent girls' ability to access information is significantly and positively associated with haemoglobin and BMI-for-age, including reduced odds of being anemic and increased odds of being overweight or obese. • The significance of different empowerment domains to girls' nutrition varies according to their geographic location (urban/rural) and in-school status. • Like married adolescent girls, level of empowerment is directly associated with single girls' level of household wealth and the country they live in. • Applying an intersectional lens and meaningfully engaging adolescent girls in intervention design using participatory methods is recommended.
Notes: LMIC = Low- and middle-income country.		

Implications for practice

This section proposes implications for practice that apply to Canadian non-governmental organizations (NGOs) that design and deliver nutrition programmes for adolescent girls, such as Nutrition International [1] and World Vision Canada.[2,3] These implications relate primarily to the need for increased investment by NGOs in monitoring and evaluating the impact of programmes designed to empower adolescent girls for improved health and nutrition.

The first implication for practitioners is that there is evidence that empowerment and nutrition are interlinked for adolescent girls in LMICs, and therefore, including empowerment-based strategies in nutrition programmes may lead to improvements in girls' nutritional status. However, we still do not have the evidence to inform which strategies are effective to help plan and design programmes. In this absence, NGOs can develop theoretical models, such as the logic model presented in Chapter 3, of the empowerment–nutrition relationship that clearly articulate the hypothesized pathways through which a programme's empowerment-based activities contribute to girls' improved empowerment and nutrition. The use of a logic model in programme design and management in the development sector is now common and facilitates the planning and conduct of programme evaluations.[4]

The second implication is that the theoretical model used to design an intervention or programme should be informed by a comprehensive assessment of the context- and individual-specific gender equality and social equity factors that contribute to adolescent girls' disempowerment and malnutrition. This research found that adolescent girls' empowerment and nutritional status are affected by their individual characteristics and their context. Gender equality and social inclusion (GESI) analysis helps NGOs to identify social norms, power relations, and systems barriers that perpetuate inequalities in a particular context. Several GESI frameworks and tools exist, including those developed by Canadian NGOs and their affiliates.[5,6] EngenderHealth's *Gender, Youth, and Social Inclusion (GYSI) Analysis Framework and Toolkit*, provides the additional advantage of including a youth analysis lens.[7]

To ensure programmes identify and address individual characteristics that may contribute to disempowerment and malnutrition, such as education level, ethnicity, sexual orientation, disability, etc., an intersectional lens should also be applied alongside a GESI framework.[8] Participatory approaches that engage adolescent girls in programme design are another important strategy for incorporating individual needs and priorities. Strategies such as participatory action research can also be empowering by building girls' capacities and engaging them as change agents in their communities.[9]

Third, robust monitoring and evaluation plans should be developed for programmes; informed by the programme's theoretical model. This thesis found that many measures along the causal chain from empowerment to improved nutrition for adolescent girls are missing from existing studies and datasets. The studies that do exist are often lacking in methodological rigour or leave out key populations, such as girls living in low-income countries or those who are out of school. Canadian NGOs can help to fill these evidence gaps by investing in high quality impact evaluations and implementation research. Inherently, nutrition programmes that include empowerment strategies are complex interventions – they may have multiple interacting components, target multiple populations, groups, and settings, measure multiple outcomes, or require tailoring and flexibility throughout implementation.[10] Guidance for developing

and evaluating complex interventions exists [11] and can be applied at the programme planning stage so that an appropriate and robust evaluation strategy is in place from the beginning of programme implementation.

When developing monitoring and evaluation plans, careful thought should be given to identifying appropriate measures for concepts along the causal chain. This thesis found that important mediating measures for the relationship between empowerment and nutrition, such as access to health services, were missing from existing studies and datasets. Using a logic model to inform the development of the monitoring and evaluation plan can help to avoid these omissions. A logic model describes theorized linkages between programme resources, activities, outputs, and immediate (shorter-term), intermediate, and longer-term outcomes, making the identification of critical outcomes for assessment easier.[4]

Consideration should also be given to assessing potential adverse effects of empowerment-based interventions. This thesis found only one intervention study that assessed adverse effects, yet the potential for negative repercussions is evident. The ESEM models in Chapters 4 and 5 showed that empowerment may lead to increased levels of overweight or obesity among adolescent girls. Other adverse outcomes, such as an increased risk of gender-based violence,[12] are also possible and need to be understood.

A final implication for Canadian NGOs is the importance of disseminating their findings. It is possible that programme monitoring and evaluation data that would have been relevant to this thesis are not publicly available. Programme evaluations may remain as internal documents, depriving the rest of the research and development assistance community from benefitting from others' experiences and lessons learned. Some NGOs are beginning to collect programme monitoring data that include gender, empowerment, and nutrition measures that could help to fill data gaps if they are more widely shared.[13]

To put these implications into practice, Canadian NGOs need appropriate levels of resources and expertise. The following section summarizes considerations for Canadian policymakers, including the need to increase investment in research as part of their support to NGOs working in global health.

Considerations for Canadian policymakers

This section applies the thesis findings to the content of Canada's Feminist International Assistance Policy (FIAP), which "recognizes that supporting gender equality and the empowerment of women and girls is the best way to build a more peaceful, more inclusive and more prosperous world."[14] A priority action area of the policy is *human dignity*, which includes a commitment to "advancing gender-sensitive nutrition" that is focused on undernutrition and micronutrient deficiencies among women, adolescents and young children.[15] The FIAP states that Canada will strengthen the evidence base by investing in policy

research, better data collection, and evaluation for gender equality.[14] This thesis has shown that increased investment in these areas is urgently needed in the context of adolescent empowerment and nutrition.

Three implications for the FIAP are proposed. First, a stronger articulation of the government's policy to address adolescent nutrition that includes strategies to empower adolescent girls is warranted. The current version of the policy does not directly address the challenges faced by adolescent girls in accessing nutritious foods or nutrition services.[15] Nor does it make an explicit link between empowering adolescent girls (or women) and improving their nutritional status. This thesis showed that the empowerment–nutrition relationship for adolescent girls is important and complex and should be considered as a challenge separate from those faced by adult women. The importance of the adolescent life stage should be recognized and specifically addressed in pursuit of the FIAP's nutrition-related goals.

Second, the Government of Canada (GoC) should consider expanding its nutrition focus in the FIAP to include addressing the challenges of overweight and obesity. Rates of overweight and obesity continue to rise among all age groups in LMICs.[16] The ESEM models in Chapters 4 and 5 showed that empowerment is also associated with increased odds of being overweight or obese for adolescent girls. It is no longer practical to focus on undernutrition only; the double burden of malnutrition is growing in LMICs, particularly among the poorest.[17]

Third, the GoC should develop a research investment strategy to underpin its commitment to strengthening the evidence base for gender equality, as outlined in the FIAP. Within this research strategy, the government can commit to funding operational research conducted by Canadian and non-Canadian nutrition partners to better understand the empowerment–nutrition relationship. This can include funding for operational research assessing the impact of nutrition programmes that take an empowerment-based approach and for the development and testing of validated measures for empowerment and nutrition. Consideration should be given to ensuring a sufficient duration of research funding to partners so that programme impact can be properly assessed.

Novelty of the thesis

This thesis represents the first comprehensive assessment of the empowerment–nutrition relationship for adolescent girls in LMICs. Each chapter within the thesis makes a unique contribution to the literature, as outlined in Table 2.

Table 2. Summary of key thesis contributions.

Chapter	Area of contribution	Unique contribution
Chapter 3	Effects of empowerment-based nutrition interventions for adolescent girls in LMICs	• Since the project was conceived in 2018, there have been no published systematic reviews of empowerment-based nutrition interventions for adolescent girls in LMICs. • The logic model describing the concept of an empowerment-based nutrition intervention and its impact on adolescent girls' nutritional status that was developed and refined through the systematic review is a unique contribution to the published literature. • A presentation of the logic model was given at the 2018 Canadian Conference on Global Health (Appendix A5)
Chapter 4	Exploratory structural equation modelling	• Since this study was conceived, no published studies have applied exploratory structural equation modelling to modelling the empowerment–nutrition relationship in adolescent girls or other populations.
	Modelling the empowerment–nutrition relationship for married adolescent girls	• This is the first published study to model the empowerment–nutrition relationship for married adolescent girls in East Africa. • The model that was developed of the empowerment–nutrition relationship for married girls for this study is a unique contribution to the published literature. • The study identified statistically significant empowerment domains associated with nutritional status that can inform decision-making by policymakers and practitioners in the field of adolescent nutrition.
Chapter 5	Modelling the empowerment–nutrition relationship for single adolescent girls	• This study applied an ESEM-in-CFA framework and included sub-group analyses which added an additional level of complexity and information compared to the model used for married adolescent girls. • This is the first study to model the empowerment–nutrition relationship for single adolescent girls in East Africa. • The model that was developed of the empowerment–nutrition relationship for single girls for this study is a unique contribution to the literature. • The study identified important individual- and context-specific factors that can influence the empowerment–nutrition relationship for single adolescent girls that can inform decision-making by policymakers and practitioners in the field of adolescent nutrition.
Notes: CFA = Confirmatory factor analysis; ESEM = Exploratory structural equation model; LMIC = Low and middle-income country.		

Strengths and limitations

While the strengths and limitations of each study that compose this thesis are described in detail in Chapters 3-5, this section provides an overview of the strengths and weaknesses of the thesis overall.

Strengths

A key strength of this thesis is that it addresses a global health priority (adolescent nutrition) and seeks to help fill an important evidence gap (operationalizing empowerment in the context of adolescent girls' nutrition). Strengths associated with each chapter are summarized in Table 3.

Table 3. Thesis strengths

Chapter	Strengths
Chapter 3	• The systematic review followed a published, peer-reviewed protocol. • A comprehensive search of published and grey literature developed by an experienced medical information specialist resulted in more than 23,000 records screened for eligibility. • The systematic review was theoretically informed and based on a logic model (published with the protocol) derived from key empowerment- and nutrition-related frameworks in the literature. • A Canadian NGO that delivers nutrition programming for adolescent girls contributed to the systematic review.
Chapter 4	• The ESEM model was theoretically informed and based on a review of other studies using similar data to measure the empowerment–nutrition relationship. • The study applied robust statistical methods, ESEM, that are more appropriate for measuring and analysing latent constructs (such as empowerment). • The study used previously validated measures of empowerment from two-stage cluster randomized, nationally-representative, Demographic and Health Surveys that are standard across countries.
Chapter 5	• In addition to sharing the same strengths as Chapter 4, this study was able to expand its analyses due to a larger sample size to look at important subgroup differences (in-school status, and urban/rural residence) in the empowerment–nutrition relationship.
Notes: ESEM = Exploratory structural equation model; NGO = non-governmental organization.	

Limitations

There are three overarching limitations that should be highlighted here: data/study availability, study quality, and methodological limitations. These challenges are discussed below in relation to each thesis objective.

Data and study availability

In assessing the impact of empowerment-based nutrition interventions for adolescent girls in LMICs, despite an exhaustive search of published and grey literature, only ten eligible studies were identified for inclusion, and only one included study assessed implementation and contextual factors. Reasons for study exclusion were wrong study design, wrong population, lack of a complete empowerment model, primary purpose is not to improve dietary intake, data not sex-disaggregated, and wrong outcomes. The generalizability of the review's findings was also limited by the lack of studies conducted in low-income countries where populations face the triple burden of undernutrition, micronutrient deficiencies, and overweight/obesity. Studies conducted with out-of-school girls were also not identified.

Regarding the ESEM models, sources of secondary data on adolescent empowerment and nutrition across multiple countries and with a sufficient sample size to allow for statistical modelling was limited to Demographic and Health Surveys (DHS), which only collects data for adolescent girls aged 15 to 19 years old. In addition, many empowerment-related variables in the DHS are only collected for married respondents (e.g., role in household decision-making). The DHS also lacks measures for other potentially important empowerment dimensions and confounders of the nutrition-empowerment relationship that could not be tested in the ESEM models. Finally, DHS data are cross-sectional – limiting causal analysis.

Study quality

The studies included in the systematic review included several methodological limitations that resulted in six out of ten included studies being rated as having a high risk of bias. The outcome quality according to GRADE [18] was downgraded due to study limitations, including unclear sequence generation and allocation concealment methods, lack of blinding, high heterogeneity, and imprecision. These limitations prevented the determination of conclusive recommendations for policy and practice, but they also allowed for the identification of important areas for future research.

Methodological limitations

Using factor analysis can limit the ability of later studies to replicate findings because this statistical method involves subjective decisions, such as the selection of the number of factors to extract and the rotation method used. These decisions can vary between researchers, leading to different factor structures. Additionally, factor analysis is sensitive to the specific sample and variables included in the study, which may not be identical in subsequent research. Consequently, these variations can result in inconsistencies and challenges in replicating the findings presented here.

Using DHS data to model empowerment presents challenges related to measurement validity and reliability that cannot be avoided. For instance, construct validity may be compromised because DHS items do not fully capture all dimensions of empowerment, resulting in an incomplete measure. Additionally, reliability issues can stem from sampling variability, as the factor structure may vary across different populations, affecting the consistency and generalizability of the findings. These limitations highlight the need to address measurement gaps and develop more comprehensive and consistent tools for assessing empowerment.

Directions for future research

In this research, many important and novel findings were discovered, as described above. However, it also identified several areas of inquiry requiring further study and investigation. Two of these areas are elaborated below.

Addressing measurement gaps along the empowerment–nutrition causal chain

This thesis used theoretical models of the empowerment–nutrition relationship to underpin its objectives, methods, and results interpretation. It found that there are currently several deficiencies in the global health community's ability to measure and model this relationship, largely due to limited data availability. One significant challenge was the lack of measures available along the proposed causal chain from empowerment to nutrition. Figure 1 presents the revised logic model from the systematic review. Boxes containing asterisks indicate outcomes that were measured by studies included in the systematic review. Measures at the output level are missing, as are measures of a supportive opportunity structure at the shorter outcome level. Outcomes related to agency, dietary intake, uptake of essential services, and healthy behaviours that were measured in the systematic review were difficult to synthesize because they were measured differently between studies. Attempts to measure empowerment were limited to measuring self-efficacy, which is just one dimension of empowerment (related to intrinsic agency).

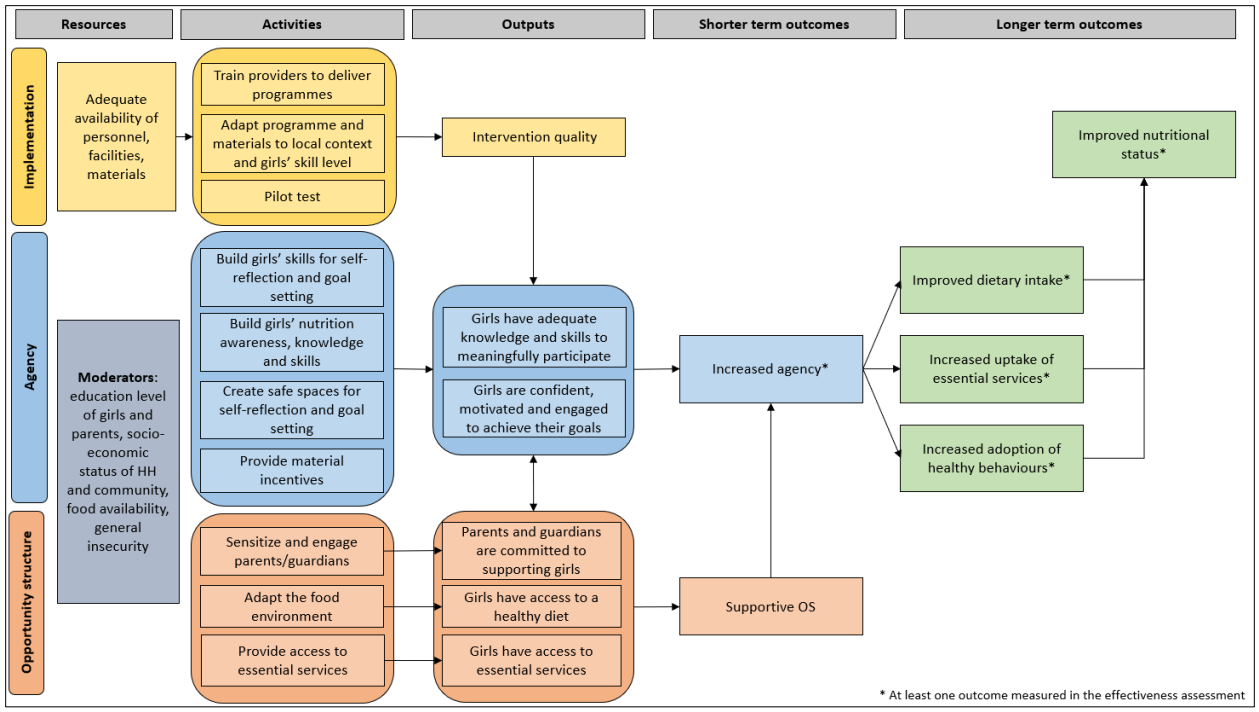


Figure 1. Revised logic model of the effects of empowerment-based nutrition interventions on adolescent girls' nutritional status.

Similarly, the models used in Chapters 4 and 5 were missing measures for potentially important empowerment concepts that apply directly to nutrition, such as decision-making power over diet (a measure of agency specific to nutritional status). Mediators, such as those that measure a supportive opportunity structure (e.g., food availability in the household), were similarly missing.

To help address these gaps, research is needed to identify and validate measures of the components of empowerment (agency and opportunity structure) as they relate to adolescent nutrition, based on a conceptual framework, such as the one proposed here. The research would need to break down and identify measures of the different sub-components of agency and opportunity structure that are relevant to adolescent nutrition. These sub-components are articulated in the logic model as the blue boxes representing potential measures of contributors to agency and orange boxes being potential measures of opportunity structure. Decision-making power over the green boxes would be demonstrations of agency, while the achievement of the green boxes would demonstrate capability in these life domains.

Undertaking high quality intervention studies in understudied populations and contexts

To complement the development of measures as outlined in the previous section, there is a need to conduct high quality impact evaluation and implementation research of empowerment-based nutrition interventions. The conceptual framework(s) used to develop measures could also be applied to

intervention design and evaluation, ensuring that a complete empowerment model (agency + opportunity structure) is applied and evaluated.

Rigorous experimental study design is needed to overcome some of the limitations found through the systematic review, such as selection bias, lack of blinding, and reporting bias. Again, guidance for developing and evaluating complex interventions can be of assistance here.[10] This includes assessing intervention implementation because a finding of a lack of effect may be due to implementation failure, as opposed to a real absence of effect.

Beyond improving on study and intervention design, where studies are conducted and in what populations also needs to be considered. Studies are needed in low-income country settings where the triple burden of malnutrition remains prominent. Studies are also needed outside of school settings – targeting out-of-school youth. Studies that target adolescent boys and girls need to sex-disaggregate their findings.

Experimental design should be complemented with the use of qualitative methods. Using qualitative or mixed-methods study designs to explore the issue of empowerment and adolescent nutrition would beneficial because these approaches capture the complexity and context of individual experiences. Qualitative methods allow for in-depth understanding of personal and cultural factors influencing nutrition and empowerment. Mixed-method designs integrate this rich qualitative data with quantitative measures, providing a comprehensive view that can inform more effective and tailored interventions.

Conclusion

This thesis provides a comprehensive examination of existing evidence of the relationship between adolescent girls' empowerment and nutrition in LMICs. It demonstrated that this relationship is significant and complex, requiring careful consideration when designing and evaluating interventions. The models that were developed, tested, and refined through this research are important contributions to the literature that can guide Canadian policymakers and NGOs in the investment, design and evaluation of interventions to empower adolescent girls for improved nutrition. While many important findings have been highlighted, important opportunities for future research are also identified, laying a solid foundation for further inquiry in this important area of research and practice.

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PROTOCOL

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PROTOCOL: The effects of empowerment-based nutrition interventions on the nutritional status of adolescent girls in low- and middle-income countries

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1 | BACKGROUND

1.1 | The problem, condition or issue

Adolescents (10 to 19 years) currently represent the largest global generation of young people in our collective history (United Nations, 2015). The regions of Africa, Asia, Latin America, and the Caribbean are the home of 1.1 billion young persons (United Nations Department of Economic and Social Affairs Population Division, 2017). In sub-Saharan Africa, people below the age of 25 make up 62% of the population, with only marginal declines predicted through 2050 (United Nations Department of Economic and Social Affairs Population Division, 2019). The working age population (25 to 64 years) in sub-Saharan Africa, Oceania, and parts of Asia, Latin America, and the Caribbean is growing faster than all other age groups (United Nations Department of Economic and Social Affairs Population Division, 2019). Ensuring the health and well-being of adolescents who will fill the ranks of the world's working age population will help to propel global economic growth and development (Patton et al., 2016).

Adolescence is a period of significant physiological change that includes marked skeletal growth, increased bone mass, and fundamental neurological development (Das et al., 2017; Patton et al., 2016). Proper nutrition during adolescence is crucial for optimal growth and development and helps to prepare adolescents for adulthood. However, many adolescents face challenges in achieving optimal dietary intake, especially in low- and middle-income countries (LMICs) where the majority of adolescents reside (WHO, 2014). Iron-deficiency anemia affects 430.7 million (24%) adolescents, with 77% of adolescents living with anaemia in multiburden countries where communicable, maternal, and nutritional conditions contribute to 2,500 disability adjusted life-years (DALYs) or more per 100,000 adolescents (Azzopardi et al., 2019). The prevalence of anaemia is consistently higher for females than males, and is more than 50% for females in Bhutan, Yemen, India, and Burkina Faso in 2016 (Azzopardi et al., 2019). Mean BMI (body mass index) and the prevalence of obesity are also rising among children and adolescents

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globally. The percentage of adolescents who are overweight or obese was 324.1 million in 2016—an increase of 176.9 million from 1990 (Azzopardi et al., 2019). The median prevalence of overweight and obesity among girls is highest in the Eastern Mediterranean region (28%), followed by the Western Pacific (25%), the Americas (25%), and Europe (21%; Akseer, Al-Gashm, Mehta, Mokdad, & Bhutta, 2017). Yet more children and adolescents are moderately or severely underweight globally, with the largest burden of underweight found in South Asia and central, east and west Africa (Abarca-Gómez et al., 2017).

The social, economic, and cultural conditions in which an adolescent matures can significantly shape their health and development, including their nutrition. The social determinants of health are the conditions in which people are born, grow, develop, live, work, and age (Viner et al., 2012). Social inequities, particularly those related to poverty and gender, can heavily influence adolescent health and well-being (Patton et al., 2016). Adolescence is a time when gender roles and norms become more heavily engrained, affecting how adolescents interact with and experience the world. The gendered experience of adolescence can vary depending on the context, as Kabeer writes: "In many LMICs, the gendered norms embedded in local structures of patriarchy come into play in heightened ways during adolescence, restricting the agency, opportunities, aspirations and social networks of young girls to a far greater extent than boys" (Kabeer, 2018). Where considerable gender inequities exist, women and girls are more likely to suffer from nutritional deficiencies than men and boys (Elder, 2003). Gender inequities can limit access to an adequate diet and lead to early marriage and high fertility rates, putting adolescent girls at greater risk of nutrient deficiencies as well as poor pregnancy and birth outcomes (Akseer et al., 2017; Bhutta et al., 2013). Numerous studies have identified a significant association between women's empowerment and women's and children's nutritional status (Alaofè, Zhu, Burney, Naylor, & Douglas, 2017; Bhagowalia, Menon, Quisumbing, & Soundararajan, 2012; Cunningham, Ruel, Ferguson, & Uauy, 2015; Na, Jennings, Talegawkar, & Ahmed, 2015; Pratley, 2016; Sinharoy et al., 2018; Smith, Ramakrishnan, Ndiaye, Haddad, & Martorell, 2003; Taukobong et al., 2016).

1.2 | The intervention

The empowerment of women and girls has been identified as way of improving the nutrition sensitivity of interventions, in addition to achieving scale and increased coverage of at-risk households and individuals (Ruel & Alderman, 2013). There is growing interest in assessing the impact of empowerment interventions on women's empowerment as well as its instrumental value in improving development outcomes, including women's and children's health and nutrition. The objective of this is review is to build on the existing literature base to examine the effects of integrating women's empowerment strategies in nutrition interventions to improve the nutritional status of adolescent girls' in low- and middle-income countries.

1.3 | Defining women's empowerment and its related components

There are various definitions of women's empowerment, illustrating the complexity of the construct (Alsop & Heinsohn, 2005; Batliwala, 1994; Kabeer, 1999; Lee-Rife, 2010; Malhotra, Schuler, & Boender, 2002; G. Sen & Batliwala, 2000; A. Sen, 1985a). A commonly used definition is that of Naila Kabeer. She defines empowerment as "the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them" (Kabeer, 2001). Kabeer identifies three interdependent components to women's empowerment. The first is agency, or "the ability to define one's goals and act upon them" (Kabeer, 2001). Alsop and Heinsohn (2005) define agency as "the ability to make meaningful choices." Similarly, A. Sen (1985b) describes agency as "what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important." Central to these definitions is (a) the availability of alternatives from which to choose, (b) the individual is aware of the alternatives available to them and (c) the individual desires to make a choice (Alsop & Heinsohn, 2005; Kabeer, 2001). Agency is often described in terms of decision-making power, but it can also reflect an ability to bargain, negotiate, influence, resist, or manipulate (Kabeer, 1999).

Kabeer (2001) identifies the second component of empowerment, *resources*, as a precondition for the ability to exercise choice (agency). Resources can be material, human or social. Alsop and Heinsohn (2005) refer to this component as *opportunity structure* , or "the formal and informal contexts within which actors operate." We will use the term "opportunity structure" to represent this second component for the purposes of this review. A supportive opportunity structure will enable an individual to make their choices a reality. For example, an adolescent girl may desire to stay in school until graduation, but she may be prevented from doing so if her father prefers her to be married.

The final component is *achievements*. Agency and opportunity structure interact to result in the achievement of an individual's desired outcomes. A. Sen (1985b) refers to this interaction as capabilities, or the potential that people have for living the lives they want. Notably, chosen actions that lead to undesired outcomes do not signify a high degree of empowerment. For example, the decision to participate in a microcredit programme may increase a woman's access to financial resources, but if her husband controls how those resources are spent, the desired outcome of financial autonomy would not be achieved.

Empowerment can take place in different dimensions of women's lives. A high degree of empowerment in one area does not automatically translate into empowerment in other areas. For instance, an adolescent girl may be able to attend school (an indicator of social empowerment) but she may be denied the right to access health care without her guardian's permission (an indicator of household or intrafamilial empowerment). There are six conceptual definitions of empowerment commonly used in the literature (Malhotra et al., 2002; Pratley & Sandberg, 2018). Below we briefly describe each and provide indicators at the individual level.

- *Economic*: Access and claims to material resources. Examples of individual-level indicators include control over one's income, access to the labour market, having a bank account, etc.
- *Political*: Inclusion in political processes and the ability to self-organise. Example indicators are the ability to organise and participate in a women's advocacy group or women's membership on a local council.
- *Legal*: Women's rights as codified in law. Example indicators are the ability to own property and the right to vote.
- *Socio-cultural*: The type and quality of relationships with other people and groups outside of the household, often highly influenced by society' gender norms. Examples include women's freedom of movement and society's commitment to girls' education.
- *Intrafamilial*: The social hierarchy and dynamics within the household. Examples are women's role in household decision-making or their sexual autonomy.
- *Psychological*: An individual's belief that they can achieve their goals. An example is an individual's perception of their own self-efficacy. This dimension is closely related to the concept of agency.

The gender equality challenges and the relevance of different empowerment dimensions will vary by context. For example, socio-cultural norms in South Asia can restrict women's ability to leave home without a male relative or chaperone. In sub-Saharan Africa, migrant labour among men is common, giving women greater levels of independence, if not actual autonomy.

1.4 | Operationalizing women's empowerment

The operationalization of women's empowerment in health and development programmes in recent years has largely focused on improving access to resources, assets, and services. Interventions that have been assessed include women's self-help groups (often with an economic focus; Atteraya, Gnawali, & Palley, 2016; Brody et al., 2015; Kabeer, 2018; Kumar et al., 2018; Lahiri-Dutt & Samanta, 2006; Vollmer, Khan, Ngoc Tu, Pasha, & Sahoo, 2017), cash transfer programmes (Adato, de la Briere, Mindek, & Quisumbing, 2000; Bonilla et al., 2017; Molyneux, 2008; Tiwari et al., 2016; van den Bold, Quisumbing, & Gillespie, 2013), microcredit programmes (Lahiri-Dutt & Samanta, 2006; Mahmud, 2003; Naser & Crowther, 2016; Swain & Wallentin, 2009; Vaessen et al., 2014; van Rooyen, Stewart, & de Wet, 2012), agriculture programmes (Olney et al., 2016; van den Bold et al., 2015), and programmes to strengthen inheritance and property rights (Allendorf, 2007; Mishra & Sam, 2016; Peterman, 2011).

Shankar, Sundar, and Smith (2019) have written about the gap in focusing specifically on agency-based interventions, that include "designing spaces that allow individuals to self-define their goals in life areas such as work, relationships, sexuality, spirituality, or financial security." Similarly, Cornwall has highlighted the neglect of building "critical consciousness" as part of women's empowerment interventions in favour of a focus on resources (Cornwall, 2016). We will build on their work by assessing the effectiveness of nutrition interventions that include activities to foster agency as well as creating a supportive opportunity structure (including access to resources) as a way to empower adolescent girls and improve their nutritional status. Further, we will summarise the contextual and implementation factors that contribute to the success or failure of these interventions.

1.5 | Empowerment-based nutrition interventions

This review will summarise the evidence concerning the effectiveness of *empowerment-based* nutrition interventions for adolescent girls in low- and middle-income countries. In other words, we will assess the effectives of nutrition interventions that include activities to (a) foster adolescent girls' *agency* and (b) create a supportive *opportunity structure* for adolescent girls' empowerment.

For the purposes of this review, we define nutrition interventions as interventions intended to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation (World Health Organisation [WHO], 2018a). Examples of eligible nutrition interventions are micronutrient supplementation (iron, folic acid, vitamins A, D, etc.), food supplementation programmes (e.g., school feeding), and nutrition education or counselling.

To be empowerment-based, the intervention must include activities to support adolescent girls' agency and activities to create a supportive opportunity structure for adolescent girls' empowerment. An intervention that fosters agency will include activities designed to increase adolescent girls' motivations and abilities to make informed decisions by providing spaces for self-reflection and identification of important life areas (Shankar et al., 2019). Such interventions enable adolescent girls' active and meaningful participation in decision-making, instil a sense of self-efficacy, and increase self-esteem and motivation to make a positive change in pursuit of strategic life goals. Examples of activities that foster agency are life skills training programmes, mentorship programmes, counselling programmes, and other programmes that create "safe spaces" for adolescent girls or equip adolescent girls to make informed strategic life decisions. Interventions can be delivered one-on-one or in a group setting and can take place in a variety of settings include at home, at school and in the community.

The intervention must also include activities to build a supportive opportunity structure. Such activities aim to alter the constraining political, economic, socio-cultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency (Alsop & Heinsohn, 2005; Malhotra et al., 2002). This includes access to and control over resources. The type of activities that are undertaken to create a supportive opportunity structure will vary by context, thus we cannot provide an exhaustive list. Instead, we have attempted to categorize activities by type according to the dimension of empowerment they seek to redress. They are:

- *Economic*: Economic activities aim to increase adolescent girls' access to and control over financial and material resources. These

include microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.

- *Socio-cultural*: Socio-cultural activities aim to redress discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intrahousehold food discrimination, and programmes to support adolescent girls' completion of secondary education.
- *Legal*: Legal activities aim to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights. This can include adolescent girls' rights to education, family planning, employment or inheritance.

Table 1 provides examples of how the three different intervention components can combine to create an eligible intervention study. Each intervention must have as its main activity a nutrition intervention aimed to improve dietary intake among adolescent girls. In addition, an eligible intervention must include agency-related activities and opportunity structure activities.

An example of a primary study that may be included in this review is the Adolescent Girls Empowerment Programme in Zambia (Hewett et al., 2017). The 2-year, multiarm cluster randomised controlled trial assessed the impact of an "asset-building framework" intervention on the empowerment and health status of girls aged 10–19 years. The intervention provided nutrition education using participatory methods (nutrition-specific component), alongside a weekly mentor-led girls groups meeting covering health, life skills and financial education (agency component), and a health voucher and savings account programme (opportunity structure component). The study assessed a series of anthropometric measures and anaemia status, as well as empowerment outcomes between the intervention and control groups.

1.6 | How the intervention might work

We hypothesise that including empowerment-related activities in a nutrition intervention will mediate the impact of underlying gender inequities that contribute to poorer health outcomes for adolescent girls and will result in greater nutritional gains compared with programmes that do not promote women's empowerment.

Our logic model is presented in Appendix A. The logic model depicts the causal pathways from the implementation of an empowerment-based nutrition intervention to improved nutrition outcomes for adolescent girls. The development of the logic model was informed by a review of existing models and conceptual frameworks on nutrition (Black et al., 2013; Kumar et al., 2018; Salam, Das, Lassi, & Bhutta, 2016; UNICEF, 2015; WHO, 2018b) and women's empowerment (Alsop & Heinsohn, 2005; Kabeer, 1999; Kumar et al., 2018; Malhotra et al., 2002; A. Sen, 1985a; van den Bold et al., 2013; Whitehead et al., 2016).

The model begins with the proposed *three elements* of an empowerment-based nutrition intervention:

1. Activities to improve dietary intake
2. Activities to foster agency
3. Activities to build a supportive opportunity structure

In the *short term*, the elements are hypothesised to lead to an expansion in an adolescent girls' awareness of the choices available to her to improve her nutritional status, and to increase her motivation to act. The nutrition-related activities will improve her awareness, knowledge and skills for the adoption of a healthy diet and positive health behaviours. The agency-related activities complement the nutrition-related knowledge she has acquired to increase her awareness and motivation to make an informed choice to improve her health and nutrition. A supportive opportunity structure will enable her to move toward action based on her choices. For example, a school-based micronutrient supplementation programme for adolescent girls that includes a peer support programme to build girls' nutrition-related knowledge and self-confidence (agency) and a sensitisation programme for parents and teachers to the importance of supplementation for adolescent girls (opportunity structure) will increase a girl's knowledge of the importance of supplementation for her health and well-being, increase her motivation to participate in the supplementation programme, and create an enabling environment that will provide the necessary resources and supports for her to participate in the programme.

In the *intermediate term*, the intervention is expected to empower adolescent girls by increasing their decision-making power, improving their access to and control over resources (human, capital, social), and contribute to the protection and promotion of their human

TABLE 1 Examples of eligible intervention studies that include all three intervention components

					Opportunity structure		
Study	Nutrition Promoting a healthy diet	Micronutrient supplementation or fortification	Agency Individual	Group	Economic	Socio-cultural	Legal
Study 1	X		X		X		
Study 2		X		X	X	X	
Study 3	X	X		X			X

rights, such as the right to health care, education, freedom of movement, freedom from violence so forth. Returning to our illustrative example, an adolescent girl will have more decision-making power because she has acquired the information that she needs to make an informed decision, she has the confidence to make a decision, and she has the support from parents and teachers to enable her decision-making. Her access to resources is also theoretically improved with the support of the adults in her life. Finally, the sensitisation of parents and teachers should help to prevent any potential restrictions on her rights that may impede her ability to participate in the programme.

Moving down the results chain, the empowerment-related outcomes are hypothesised to feed into improved health and nutrition behaviours, improved access to a nutritious diet, and improved access to essential health services. In the case of our example, an intermediate outcome would be adolescent girls' taking micronutrient supplements consistently because they have decided it is important to them, and their environment supports them to do so. And in the *longer term*, the intervention would lead to improved dietary intake and improved nutritional status.

The exact causal pathways will vary depending on the intervention design which should be informed by the context and the particular gender-related barriers present. While we have focused this systematic review on interventions to improve dietary intake, the logic model includes pathways to improved nutritional status via improved access to essential health services for the prevention of diseases that contribute to malnutrition (e.g., malaria) and the prevention of early pregnancy—a significant contributor to malnutrition among adolescent girls (Black et al., 2013).

Promoting women's empowerment can also potentially lead to adverse effects. For example, adolescent girls, empowered to choose their own diets, may opt to consume low-nutrient foods, such as sugar-sweetened beverages (Akseer et al., 2017). There may also be backlash within the household or community in response to adolescent girls' attempts to assert increased autonomy, which may be perceived as threatening traditional power structures. Capturing the adverse effects of the intervention is a critical component to be explored that will assist in intervention design that maximises benefits and minimises harms.

Underpinning the logic model are the individual-level, household/community-level, and macro-level factors that can moderate the expected outcomes along the causal pathway. At the individual level, socially stratifying factors that contribute to health inequities have the potential to place additional barriers to proper nutrition for adolescent girls and need to be considered in intervention design and evaluation. The PROGRESS-Plus framework (O'Neill et al., 2014) is a useful pneumonic summarising these factors: Place of residence, Race/ethnicity/culture/language, Occupation, Gender/sex, Religion, Education, Socioeconomic status, and Social capital. The "Plus" stands for other personal characteristics (e.g., age or disability), features of relationships (e.g., children of parents who smoke), and time-dependent relationships (e.g., recently out of hospital) that can make an individual more vulnerable to poor health. Moving up one level, household and community characteristics can affect intervention design and results as well. Things to consider include household food security and water and sanitation facilities, the availability of health services in the community, women's representation in community leadership or other governing bodies, and other community gender norms, such as son preference. Finally, consideration of the macro-level context includes such things as the national or regional food environment and food security, national gender-related laws, policies, and institutional practices such women's rights to land ownership, and women's participation in the economy. The exact strategies necessary to foster agency and opportunity structure are highly context-specific and point to the importance of understanding not only how women's empowerment affects nutrition outcomes, but also how these contextual factors influence intervention effectiveness.

A final element to consider are the implementation factors regarding the intervention itself (Cargo et al., 2018). These include the intervention setting and delivery platform (e.g., school, health facility, community, etc.), the intervention provider (e.g., teacher, community leader, facility based health worker, community health worker, etc.), how participants were recruited, participant retention strategies and attrition rates, the reach and dose of the intervention, fidelity to intervention design, and the adaptability of the intervention to the local context and circumstances.

1.7 | Why it is important to do the review

There is a rapidly expanding body of literature on women's empowerment and health, including nutrition. Below we summarise existing reviews of interventions related to women's empowerment and nutrition in low- and middle-income countries. Our systematic review will contribute to the existing evidence-base by: (a) focusing on the role of empowerment in adolescent girls' nutrition (an understudied population), (b) attempting to separate out the role of agency-related and opportunity structure-related activities in the empowerment process, and (c) systematically reviewing and synthesising the evidence on the contextual and implementation factors that may help to explain the success or failure of empowerment-based nutrition interventions.

1.8 | Reviews

van den Bold, Quisumbing, and Gillespie (2015) conducted a review of nutrition-sensitive structural interventions (cash transfer, agriculture, and microcredit programmes) to assess their impact on women's empowerment and infant and child nutrition, and found that, despite the existence of considerable evidence depicting the associations between women's empowerment and nutritional status, more research is needed to understand the pathways that connect the two concepts. The review did not examine outcomes for adolescent girls.

Similarly, Taukobong et al. (2016) reviewed the literature across six sectors, including nutrition, to assess whether addressing gender inequalities and empowering women and girls improves health and

development outcomes. They identified common gender equality and women's empowerment variables that repeatedly emerged as significant predictors of sector outcomes, including control over income, decision-making power, and education, but also identified the need for more research into mechanisms through which gendered interventions might work. The review did not examine outcomes for adolescent girls.

Brody et al. (2015) conducted a systematic review of economic self-help group programmes for improving women's empowerment. They concluded that self-help groups have positive effects on women's economic, social, and political empowerment. Qualitative findings indicated that the poorest women were less likely to participate due to time constraints and fears of racial or caste discrimination. The review did not assess the impact of economic self-help groups on health or nutrition outcomes for women.

Kumar et al. (2018) conducted a review of women's group-based programmes and nutritional change in South Asia. They mapped interventions to four conceptual pathways (income, agriculture, health and nutrition behaviour change, and rights) from women's groups to improved nutritional status among women and children. They found the strongest evidence linking the behavior change pathways to improved nutritional status, but also noted a number of challenges in assessing the evidence based including the lack of rigorous studies, difficulties in disentangling the effects of group-based activities with other aspects of the intervention, a paucity of studies targeting nutritionally vulnerable age groups, and programmes with insufficient reach and duration. They recommend that implementers and evaluators identify a priori which change pathways they anticipate to activate and measure processes and impacts accordingly. The review did not examine outcomes for adolescent girls. conducted a review of women's group-based programmes and nutritional change in South Asia (Kumar et al., 2018). They mapped interventions to four conceptual pathways (income, agriculture, health and nutrition behaviour change, and rights) from women's groups to improved nutritional status among women and children. They found the strongest evidence linking the behavior change pathways to improved nutritional status, but also noted a number of challenges in assessing the evidence based including the lack of rigorous studies, difficulties in disentangling the effects of group-based activities with other aspects of the intervention, a paucity of studies targeting nutritionally vulnerable age groups, and programmes with insufficient reach and duration. They recommend that implementers and evaluators identify a priori which change pathways they anticipate to activate and measure processes and impacts accordingly. The review did not examine outcomes for adolescent girls. conducted a review of women's group-based programmes and nutritional change in South Asia (Kumar et al., 2018). They mapped interventions to four conceptual pathways (income, agriculture, health and nutrition behaviour change, and rights) from women's groups to improved nutritional status among women and children. They found the strongest evidence linking the behavior change pathways to improved nutritional status, but also noted a number of challenges in assessing the evidence based including the lack of rigorous studies, difficulties in disentangling the effects of group-based activities with other aspects of the intervention, a paucity of studies targeting nutritionally vulnerable age groups, and programmes with insufficient reach and duration. They recommend that implementers and evaluators identify a priori which change pathways they anticipate to activate and measure processes and impacts accordingly. The review did not examine outcomes for adolescent girls.

Brandstetter, Rüter, Curbach, and Loss (2015) conducted a systematic review of the various ways of applying the empowerment concept to healthy nutrition in health promotion. The included eight studies that were all based in high-income countries. They found diversity in the way the concept of empowerment was operationalized, in the integration of other theoretical frameworks (e.g., socio-cognitive theory), and reporting in the methods of operationalizing and measuring empowerment.

The WHO Guideline, "Implementing effective actions for improving adolescent nutrition" (WHO, 2018a), summarises the global evidence for addressing malnutrition in adolescents. The guideline identifies implementing interventions to empower adolescent girls may prevent early marriage and pregnancy, reduce sexual coercion, and notes that community stakeholders (including teachers and health workers) need to support the empowerment of adolescents to adopt and maintain optimal nutrition and health practices. The guideline further identifies as a research gap the assessment of impact of interventions and policies on autonomy, positive development, empowerment and engagement of adolescents.

Recent systematic reviews of adolescent nutrition interventions (Bhutta et al., 2013; Lassi, Moin, Das, Salam, & Bhutta, 2017; Salam, Hooda, et al., 2016) have shed valuable light on the effectiveness of nutrition interventions in improving adolescent health, but they have not specifically assessed the role of empowerment in adolescent health and nutrition.

1.9 | Protocols

Vollmer et al. (2017) have published a protocol for a systematic review of the effect of women's economic empowerment on children's health and education.

2 | OBJECTIVES

The primary objective of the review is to answer the following:

1. Does promoting women's empowerment within nutrition interventions improve the nutritional status of adolescent girls in low- and middle-income countries?
2. What are the factors influencing the success or failure of these interventions? The secondary objective is to answer the following:
3. What are the underlying empowerment-related programme theories that influence intervention design? How is empowerment defined, operationalized, and measured?
4. What is the effect of promoting women's empowerment in nutrition sector interventions on adolescent girls' empowerment-related outcomes?
5. What are the potential adverse effects of promoting women's empowerment in nutrition sector interventions on adolescent girls' health and well-being?

3 | METHODOLOGY

This review will apply a segregated mixed methods research synthesis design (MMRS). An MMRS combines qualitative, quantitative, and mix-method primary-level studies and applies a mixed methods approach to synthesise and integrate the studies' results (Heyvaert, Hannes, & Onghena, 2017). This design is more appropriate for the study of interventions that consist of multiple components as it helps to better understand how the different components are related and interact with each other (Heyvaert et al., 2017).

Through a comprehensive literature search, we will identify relevant literature with qualitative and quantitative study designs that will be segregated at the screening phase. Qualitative and quantitative studies will be analysed and synthesised separately, while the implications for practice, policy, and research that will form the discussion and conclusion sections of the review will draw on both the qualitative and quantitative syntheses.

3.1 | Criteria for including and excluding studies

3.1.1 | Types of study designs

The following study designs will be included to answer **Research Question 1** (effectiveness assessment):

- Randomised Controlled Trials (RCTs)
- Cluster Randomised Controlled Trials (cRCT)
- Controlled before and after studies (CBAs)
- (Controlled) interrupted time series (CITS, ITS)
- Propensity score matching (PSM) on baseline covariates
- Regression discontinuity design (RDD)
- Difference in difference using regression techniques (DID)
- Interventions with a synthetic control group
- Other quasi-experimental designs with at least one comparison group

Studies without an observable comparator or credible means for controlling for selection bias will be excluded.

To answer *Research Question 2*, we will include companion quantitative and qualitative studies that assess the contextual and implementation factors influencing the effectiveness of the studies screened in to the effectiveness assessment (Research Question 1).

We will include qualitative studies that explore the perspectives of intervention participants (adolescent girls), (those who delivered the intervention) providers, or administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors contributing to intervention success or failure using focus groups, in-depth interviews or participant observation. Eligible qualitative study designs include case studies, ethnographic research, grounded theory, and other thematic approaches to qualitative data analysis. Qualitative studies that do not report a clear methods and results section will be excluded. This includes opinion pieces and editorials. Eligible quantitative study designs that assess the implementation of included studies are process evaluations, surveys of intervention participants, providers, administrators, and other programme-related documents such as monitoring and evaluation reports.

Studies that apply a mixed methods design will be included where the qualitative and quantitative study components are reported separately.

3.1.2 | Types of participants

The review target population is adolescent girls (10 to 19 years) residing in low- and middle-income countries, regardless of health status.

The classification of countries as low- or middle-income will be based on the World Bank income groups as defined at the time the studies were conducted. Studies undertaken in high-income countries will be excluded.

3.1.3 | Types of interventions

Eligible studies will be empowerment-based nutrition interventions to improve dietary intake among adolescent girls. More specifically, we will include interventions whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation. Examples of eligible nutrition interventions are:

- Micronutrient supplementation or fortification interventions (iron, folic acid, iron–folic acid (IFA), calcium, vitamin D, vitamin A, zinc, iodine, and multiple micronutrients)
- Nutrition education or counselling interventions, and
- Supplementary nutrition programmes such as school feeding.

To be considered "empowerment-based," the nutrition intervention must include one or more activities intended to foster adolescent girls' agency, and one or more activities to create a support opportunity structure for adolescent girls' empowerment.

We define activities to foster agency as those that "provide spaces for self-reflection and identification of important life areas" (Shankar et al., 2019) and equip adolescent girls to make informed strategic life decisions. Examples of activities that may foster adolescent girls' agency include, but are not limited to:

- Counselling programmes
- Mentorship programmes
- Leadership training
- Life skills training
- Technical or occupational skills training

These programmes may be delivered one-on-one (e.g., individual mentorship or counselling) or in a group setting such as girls' clubs or other peer support or participatory action groups.

We define activities to create a supportive opportunity structure as those that aim to alter the constraining political, economic, socio-cultural, interpersonal, and/or legal structures (informal or formal) at the household, community, or broader societal levels, as necessary, to support adolescent girls to exercise agency (Alsop & Heinsohn, 2005; Malhotra et al., 2002). Examples of opportunity structure activities include, but are not limited to:

1. *Economic*: Economic activities aim to increase adolescent girls' access to and control over financial and material resources. These include microcredit programmes, cash transfer programmes, agriculture programmes, homestead or community gardening programmes, and savings and loan programmes.
2. *Socio-cultural*: Socio-cultural activities aim to redress discriminatory gender norms, customs and practices that restrict adolescent girls' ability to exercise agency, most often at the household and community level. Examples include activities to prevent child marriage, programmes to improve freedom of movement, male or in-law engagement strategies to reduce intra-household food discrimination, and programmes to support adolescent girls' completion of secondary education.
3. *Legal*: Legal activities aim to establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights. This can include adolescent girls' rights to education, family planning, employment or inheritance.

Nutrition-sensitive interventions, such as water, sanitation, and hygiene (WASH) programmes, agriculture programmes including community gardens, cash transfer programmes, food security programmes, and family planning programmes will be considered for inclusion if they serve as a delivery platform for an intervention whose primary aim is to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation and include activities to foster adolescent girls' agency.

3.1.4 | Comparison

Studies that have a clearly defined comparison group for evaluation of the treatment effect will be included.

3.1.5 | Types of outcome measures

The primary outcomes for the effectiveness assessment (Research Question 1) will be measures of adolescent girls' nutritional status, including:

- Change in body mass index (BMI)
- Change in BMI-for-age z-score
- Change in mid-upper arm circumference (MUAC)
- Change in haemoglobin (g/L)
- Change in serum ferritin
- Change in anaemia status
- Change in serum vitamin A

Secondary outcomes measures for Research Question 1 are:

- Changes to dietary intake, including micronutrient intake
- Improved access to a nutritious diet
- Improved health behaviours
- Increased access or use of essential health services

We will only include studies that report at least one outcome for our population of interest.

To answer Research Question 2, our outcomes of interest are the perspectives of intervention participants (adolescent girls), providers (those who delivered the intervention), and administrators (those who provided oversight or funding to the intervention) on the contextual and implementation factors that affected intervention success or failure. These data may be qualitative, in the form of in-depth interviews, focus groups, or participant observation, or quantitative from surveys, process evaluations, and other project documentation.

To answer Research Question 3, we will extract details on the empowerment-related theories, as described by primary study authors, that were used to inform the development of the women's empowerment-related activities. We will extract information on the activities that primary authors describe as promoting women's empowerment and the primary authors' rationale for adopting specific empowerment-related activities.

For Research Question 4, we will extract and analyse information on the empowerment dimensions and indicators used in studies to assess the impact of the empowerment-related activities on adolescent girls' empowerment outcomes. We will use the following definitions of empowerment dimensions, adapted from Brody et al. (2015) and Malhotra et al. (2002). We will classify empowerment indicators by their respective empowerment dimension for analysis.

- *Economic*: The ability to access, own, and control resources. Potential measures include adolescent girls' control over own income; relative contribution to family support; access to and control of family resources; participation in paid employment.
- *Political*: The ability to participate politically at the local, regional, or national level. Potential measures include knowledge of the political system and means of access to it; domestic support for political engagement; exercising the right to vote (if of legal age).
- *Socio-cultural*: The ability to overcome discriminatory gender norms at the household and community levels. Potential measures include: Adolescent girls' freedom of movement; lack of discrimination against daughters in the household; household commitment to educating daughters.
- *Intrafamilial*: The ability to exert power and influence in the household. Potential measures include control over sexual relations; ability to make childbearing decisions, use contraception, access abortion; control over spouse selection and marriage timing; freedom from domestic violence.
- *Legal*: The ability to access rights and entitlements under the law. Potential measures include knowledge of legal rights; domestic support for exercising rights.
- *Psychological*: The ability to make choices and act on them. Potential measures include self-esteem; self- efficacy; psychological well-being.

Finally, to answer Research Question 5, we will extract information on the negative or adverse effects of promoting women's empowerment in nutrition interventions for adolescent girls. These include gender-based violence, discrimination, demotivation, and adoption of unhealthy eating habits (e.g., increased consumption of sugar-sweetened beverages).

3.1.6 | Duration of follow-up

We will include studies of any follow-up duration and will conduct sensitivity analyses by length of follow-up to test the sustainability of treatment effect.

3.1.7 | Types of settings

Interventions delivered at home, in the community, in school, in the workplace, or in health facilities will be eligible for inclusion.

3.1.8 | Language

No language restrictions will be applied.

3.1.9 | Publication date

No publication data restrictions will be applied.

3.2 | Search strategy

A comprehensive search strategy was developed with the assistance of an information specialist (Appendix B). Keywords used to develop the search strategy include variations on the following: "power," "empowerment," "self-efficacy," "self-determination," "personal autonomy," "agency," "women's status," "women's rights," "malnutrition," "underweight," "overweight," "diet," "micronutrient," "vitamin," "nutrition education," "school feeding," "food supplementation," "women," "girls," "female," "maternal," "adolescent," "teenager," "youth."

3.2.1 | Databases

An experienced medical information specialist will develop and test the search strategy using an iterative process in consultation with the review authors. Another senior information specialist will peer review the search strategy prior to execution using the PRESS Checklist.

We will use a combination of controlled vocabulary (e.g., "Power [Psychology]," "Women's Rights," "Nutritional Status") and key words (e.g., empower, female status, and diet) for the concepts in all searches. We will apply the Cochrane filter for low- and middle-income countries. Vocabulary and syntax will be adjusted as necessary across the databases. We will remove animal-only and opinion pieces from the results whenever possible.

Using the OVID platform, we will search Ovid MEDLINE®, including Epub Ahead of Print and In-Process & Other Non-Indexed Citations, Embase Classic + Embase, PsycINFO, and the following EBM Reviews databases: Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Health Technology Assessment, and the NHS Economic Evaluation Database. We will also search CINAHL (Ebsco platform), Web of Science, and Popline.

We will document the search process in enough detail to ensure that it can be reported correctly in the review/update, including reporting the month and year the search began and ended.

Grey literature and hand searching:

To identify potentially relevant unpublished materials, we will contact the following research groups and organisations, and/or consult their respective websites:

- World Health Organisation Library (includes LILACS)
- Epistemonikos
- 3ie Impact and Systematic Review repositories
- E-Library of Evidence for Nutrition Actions (eLENA)
- UNICEF
- World Food Programme

- UNFPA
- International Food Policy Research Institute (IFPRI)
- Global Alliance for Improved Nutrition (GAIN)
- Nutrition International
- SPRING Project
- International Centre for Research on Women (ICRW)
- UN Women
- Gender and Adolescence: Global Evidence (GAGE) Programme
- U.K. Department of International Development (DfID)
- Bill and Melinda Gates Foundation
- Plan International
- CARE
- Save the Children
- World Vision
- Young Lives
- Emergency Nutrition Network

Citation and reference lists

The citation and reference lists of included references, including other reviews, will be searched. "Related articles" features of searched databases will be used, where applicable. We will conduct forward citation tracking using Scopus.

Contacting experts

We will contact authors of included studies to ask for suggested studies.

Screening of studies

Study selection will be conducted in duplicate by two independent reviewers using the Covidence platform (www.covidence.org). Titles and abstracts resulting from the search strategy will be independently screened by two reviewers in the first phase, followed by independent full-text review of eligible studies, also in duplicate. Any discrepancies between the independent reviewers will be resolved by consensus, and in cases of disagreement, a third author will be consulted. A PRISMA study selection flow chart (Moher, Liberati, Tetzlaff, & Altman, 2009) will be prepared, and a list of excluded studies will be compiled detailing the reason for each study's exclusion.

To minimise the risk of excluding eligible studies, we will screen for nutrition-related activities only at the title and abstract phase. In other words, we screen in all studies that aim to improve dietary intake among adolescent girls by promoting a healthy diet or providing additional micronutrients through fortification or targeted supplementation when screening titles and abstracts. At the full-text screening stage we will further screen for the agency and opportunity structure components to determine study eligibility.

In instances where articles do not provide a sufficient description of the intervention to determine its eligibility, we will look for companion articles describing the intervention or contact the authors for additional information. Where we cannot obtain additional information on the intervention, the studies will be excluded from the review.

3.3 | Description of methods used in primary research

The following study is an example of the expected eligible primary research methods:

Hewett et al. (2017): Multiarm cluster-RCT across 10 sites in four provinces of Zambia with randomisation to four different study arms (Intervention Arm 1, Intervention Arm 2, Intervention Arm 3, Control). The sites were evenly split between urban and rural settings (five sites each). The intervention assessed the effectiveness of the Adolescent Girls Empowerment Programme (AGEP), which consisted of weekly mentor-led girls' group meetings of 20 to 30 adolescent girls, participating over 2 years using curricula on sexual and reproductive health and life skills, financial literacy, and nutrition. Two additional components were a health voucher and bank account. Clusters were defined by national Census Supervisory Areas (CSAs) that were randomly selected to the experimental and control arms through a public lottery. Allocation concealment was unclear. Baseline behavioural surveys and biological specimen collection were conducted at the beginning of the trial, reassessed immediately after the programme ended (2015), and evaluated again at the 2-year follow-up point (2017). It is unclear if a cluster-adjustment method was applied (Hewett et al., 2017).

3.4 | Criteria for determination of independent findings

Where studies report different outcomes, these will be pooled in separate meta-analyses. If there are several publications reporting on the same study, we will use effect sizes from the most recent publication. In cases where several studies use the same data set or multiple outcomes are reported within the same study, we will select the study that provides the lowest risk of bias in attributing impact. Where studies include multiple outcome measures to assess related outcome constructs, we will select the outcome that appears to most accurately reflect the outcome construct of interest (Macdonald, Higgins, & Ramchandani, 2006). For studies in which multiple effects over time are reported, a variance estimation meta-analysis will be conducted. For studies having multiple treatments with only one control group, where the treatments might represent separate treatment constructs, we will calculate the effect size for each pair of treatment versus control separately.

3.5 | Details of study coding categories

The quality assessment of included studies and data extraction will be done by two independent reviewers.

3.5.1 | Quality assessment

We will use the risk of bias tool developed by the International Development Coordinating Group (IDCG) secretariat to assess risk of bias, similar to Baird, Ferreira, Özler, and Woolcock (2013). This tool has been developed to assess the risk of bias for a range of

experimental and quasi-experimental studies. The tool assesses risk of bias in the following categories:

- Selection bias and confounding
- Spill-overs/crossovers/contamination
- Outcome reporting
- Analysis reporting
- Other risks of bias, including unit of analysis errors, detection bias and placebo effects, motivation and courtesy biases, coherence of results, and others.

Judgements made on risk of bias in quantitative studies will be supported by specific information extracted from the study being assessed. An overall level of evidence quality (high, moderate, low, and very low) for the entire body of evidence will be assigned as part of the GRADE process (Atkins et al., 2004).

We will assess the quality of qualitative studies using the Critical Appraisal Skills Programme (CASP) qualitative appraisal research tool (Critical Appraisal Skills Programme, 2013). The GRADE-CERQual approach will be used to assess the overall confidence in the qualitative evidence synthesis (Lewin et al., 2015). GRADE-CERQual provides an assessment of confidence regarding the extent to which the research finding is likely to be substantially different from the phenomenon of interest. A level of confidence in the review findings will be assigned, ranging from high, moderate, low to very low confidence (Lewin et al., 2015).

3.5.2 | Data extraction

Data extraction will be conducted in duplicate by two independent reviewers. Both reviewers will use a prepiloted data extraction form. Discrepancies between the two extractors will be resolved through discussion or by consultation with a third reviewer. See Appendix C for draft codebooks that will guide data extraction.

The following information on intervention design will be extracted:

- The intervention setting, e.g., school, community, home, workplace so forth.
- The intervention administrator, e.g., foreign government, national or local government, nongovernmental organisation, community-based organisation so forth.
- The intervention provider, e.g., community health worker, health facility staff, teachers, peers so forth.
- Descriptions of any training given to intervention providers before and during the intervention
- Description of any prior needs assessment to inform intervention design
- Participant recruitment procedures
- Participant attrition rate and reasons for attrition
- Activities undertaken to design the intervention in a culturally-sensitive manner
- Intervention reach (the degree to which participants are present and participate)
- Intervention dose (frequency, intensity and duration of intervention delivery to participants)
- Intervention integrity/fidelity (degree to which the intervention was delivered according to original design)
- Intervention adaptation (adaptation during implementation to respond to changing circumstances)
- Contamination (unintentional delivery of intervention to comparison group or failure to provide intervention to intervention group
- Cointervention (unintentional delivery of another intervention to study population)
- Participant engagement (active participation and receptivity to the intervention)
- Intervention quality
- Contextual factors that shape implementation effectiveness (e.g., level of food insecurity)
- Authors' definition of empowerment and rationale for incorporating empowerment-related activities

For quantitative outcomes, we will extract the following:

- For dichotomous outcomes, we will extract the total number of participants in the treatment group and the total number experiencing the event to allow the calculation of odds ratios and relative risks (or data necessary for their calculation).
- For normally-distributed, continuous outcomes, we will extract means, standard deviations (or data necessary for their estimation) and the number of participants in each treatment group.
- For skewed continuous data, we will extract medians, ranges, and *p* values. Outcomes that were measured at different time points will be recorded separately.

For measures of empowerment, we will extract definitions of the measures used, the empowerment dimensions being measured (according to the primary authors), and the primary authors' rationale for outcome selection.

We will extract data on socioeconomic status, education level, race/ethnicity/caste, place of residence (urban, rural, slum, remote), and other potential effect moderators for subgroup analyses based on the PROGRESS-Plus framework (O'Neill et al., 2014).

Quantitative data will be entered into RevMan5 and checked for accuracy.

For qualitative studies, we will extract the views, experiences, and opinions of intervention participants, implementers and administrators on factors influencing the success or failure of interventions. Emphasis will be placed on ascertaining the feasibility, appropriateness, and meaningfulness of the women's empowerment components of the intervention.

3.6 | Statistical procedures and conventions

Quantitative data will be synthesised using meta-analysis, where appropriate. We expect a high level of heterogeneity due to the fact that studies may employ a variety of different nutrition, agency, and

opportunity structure activities. Consequently, we will use a random-effects model to produce an overall summary estimate, if an average treatment effect across studies is considered meaningful. Where meta-analysis is not possible or is deemed inappropriate, results will be reported using narrative synthesis, giving effect sizes and confidence intervals, where applicable (Popay et al., 2006).

We will assess heterogeneity among studies by first examining the heterogeneity at face-value in terms of the studies' populations, interventions, and outcomes. Second, we will use τ^2 to statistically test heterogeneity between studies. τ^2 is the variance of the effect size parameters across the population of studies and reflects the variance of the true effect sizes (Borenstein, Hedges, Higgins, & Higgins, 2009).

The accuracy of numeric data will be checked by comparing the magnitude and direction of effects reported by studies and how they are presented in the review. A statistically nonsignificant p value will be interpreted as a finding of uncertainty unless confidence intervals are sufficiently narrow to rule out an important magnitude of effect.

Our base-case analysis will include all interventions regardless of nutrition, agency or opportunity structure intervention. If there is a sufficient number of studies, we will conduct the following sensitivity analyses based on intervention design (Table 2).

Should the number of studies warrant, we will further split the interventions and run further sensitivity analyses. For example, we will consider sensitivity tests that break down all three intervention elements. Otherwise, we will provide a narrative summary.

We will combine experimental and quasi-experimental designs for analysis and conduct a sensitivity analysis by study design. We will use David Wilson's effect size calculator for quasi-experimental study outcomes to allow for combining of experimental and quasi-experimental study outcomes for meta-analysis (Lipsey, 2001). Primary and secondary outcome data will be extracted and analyzed separately. Binary outcomes (e.g., anaemia status) will be analyzed using risk ratios (±95% confidence interval [CI]). Continuous outcomes (e.g., height and weight) will be analyzed using mean differences (±95% CI) and standardised mean differences when different units are used (e.g., measures of dietary diversity or empowerment indicators). In the random effects meta-analysis, Mantel-Haenszel (M-H) methods will be used for binary outcomes, and the Inverse-Variance (I-V) method will be used for continuous outcomes. Where studies use different metrics for the same outcome, e.g., anemia status (binary) vs haemoglobin (continuous), we will convert to the same metric using Borenstein's conversion formulae (Borenstein et al., 2009) and synthesise.

Unit of analysis errors will be investigated to ensure estimates are properly adjusted for clustering. Where analyses are not adjusted for clustering, estimates will be adjusted using values of intra-cluster correlations from the literature. An intention-to-treat analysis will be conducted. We will document how authors treated missing data, and the effect of missing data on the overall results will be assessed through sensitivity analysis.

We will conduct moderator analyses on the following:

- Risk of bias (low, unclear, and high)
- Study duration
- Low-income country vs. middle-income country
- Geographic region (Africa, Asia, and Latin America)
- Study design (RCT vs. NRS)
- Group vs. nongroup interventions
- Marital status (single, currently partnered, divorcee/separated/widowed)
- Number of children (0 vs. 1+)
- Education level (none, some primary, primary complete, some secondary, secondary complete, and higher)
- Age (10–14 y vs. 15–19 y)

A formal statistical test will be used to test differences between outs. For subgroups defined by binary or nominal categories, we will use the Cochran Q-test. For ordinal categories, multi-level meta-analysis will be conducted. The results of all subgroup testing will be reported, regardless of results.

If more than ten studies meet our eligibility criteria, we will assess the presentation of publication bias using a visual inspection of funnel plots. Statistical support will be provided by a statistician, and meta-analyses will be conducted using RevMan5 software (The Cochrane Collaboration). Results will be displayed using forest plots.

The level of evidence will be considered when formulating the review's conclusions. Where possible, differences in results will be explained by giving a description of likely explanatory factors. We will prepare a GRADE summary of findings table (Schunemann, Brozek, Guyatt, & Oxman, 2013).

TABLE 2 Sensitivity tests by intervention design

Test	Nutrition	Agency	Opportunity structure
Base case	All nutrition activities combined	All agency activities combined	All opportunity structure activities combined
Test 1	All nutrition activities combined	All agency activities combined	Opportunity structure activities split by dimension
Test 2	All nutrition activities combined	Agency activities split by group vs nongroup activities	All opportunity structure activities combined
Test 3	Nutrition activities split by promotion of a healthy diet, providing additional micronutrients, or a combination of both	All agency activities combined	All opportunity structure activities combined

3.7 | Treatment of qualitative research

We will use the "best fit" framework synthesis method to synthesise data (Carroll, Booth, Leaviss, & Rick, 2013; Harden et al., 2018). The "best fit" framework synthesis method allows for the testing or adaption of an existing model to a potentially different population. For this review, we have adapted existing models for nutrition and women's empowerment to develop a logic model (described earlier) for adolescent girls' empowerment and nutrition, and plan to test its applicability through the systematic review process. We will code qualitative data from the review's included studies against the conceptual framework at each level of the conceptual framework:

1. Elements of the approach
   a. Nutrition-related activities
   b. Agency-related activities
   c. Opportunity structure activities
2. Outputs (or implementation factors)
   a. Intervention setting
   b. Intervention administrator
   c. Intervention provider
   d. Provider training
   e. Prior needs assessment to inform intervention design
   f. Participant recruitment procedures
   g. Participant attrition rate and reasons for attrition
   h. Activities undertaken to design the intervention in a culturally-sensitive manner
   i. Intervention reach
   j. Intervention dose
   k. Intervention integrity/fidelity
   l. Intervention adaptation
   m. Contamination
   n. Cointervention
   o. Participant engagement
   p. Intervention quality
3. Shorter-term outcomes
   a. Increased ability and motivation to make and act on informed choices to improve nutritional status
   b. Supportive home and community environment to support adolescent girls' choices
   c. Improved awareness, knowledge and skills for the adoption of a healthy diet and positive health behaviours
4. Intermediate-term outcomes
   a. Increased decision-making power
   b. Increased access to or control over resources
   c. Protection and fulfilment of human rights
   d. Improved access to a nutritious diet
   e. Increase use of essential health services
   f. Improved health behaviours
5. Longer-term outcomes
   a. Improved dietary intake
   b. Reduced risk of disease, infection, injury, and early pregnancy
   c. *Adverse effects*
6. Contextual factors
   a. Macro-level
   b. Community level
   c. Household level
   d. Individual level

Inductive, thematic analysis techniques will be used to synthesise data that do not align to the existing themes in the logic model. Emphasis will be placed on understanding the role that promoting women's empowerment in the nutrition sector programme had on intervention success or failure, with a focus on aspects regarding the feasibility, appropriateness and meaningfulness of the empowerment-related activities or strategies that were employed.

The conclusions drawn from the quantitative and qualitative syntheses will be combined to inform the review's final discussion and conclusions. The logic model will be revised based on the review's conclusions. The review's discussion will include reflections on the review's policy and future research implications.

ROLES AND RESPONSIBILITIES

Please give a brief description of content and methodological expertise within the review team. It is recommended to have at least one person on the review team who has content expertise, at least one person who has methodological expertise and at least one person who has statistical expertise. It is also recommended to have one person with information retrieval expertise. Please note that this is the *recommended optimal* review team composition.

- Content: A. Y. R., Z. A. B., C. V., E. K., A. K. R., C. M. K.
- Systematic review methods: G. A. W., V. W., E. K.
- Statistical analysis: G. A. W., M. T.
- Information retrieval: B. S.

SOURCES OF SUPPORT

The lead author (A. Y. R.) is the recipient of a graduate studentship award from the Bruyère Research Institute, and a PhD grant from Nutrition International.

DECLARATIONS OF INTEREST

A. Y. R., C. M. K., A. K. R., Z. B., C. V., E. B., C. K., and L. S. have no conflicts of interest to declare. V. W. is the Editor-in-Chief of the Campbell Collaboration.

PRELIMINARY TIMEFRAME

Approximate date for submission of the systematic review: March 2020.

PLANS FOR UPDATING THE REVIEW

The review will be updated every two years. AYR will be responsible for updating the review.

AUTHOR DECLARATION

Authors' responsibilities

By completing this form, you accept responsibility for preparing, maintaining and updating the review in accordance with Campbell Collaboration policy. Campbell will provide as much support as possible to assist with the preparation of the review.

A draft review must be submitted to the relevant Coordinating Group within two years of protocol publication. If drafts are not submitted before the agreed deadlines, or if we are unable to contact you for an extended period, the relevant Coordinating Group has the right to deregister the title or transfer the title to alternative authors. The Coordinating Group also has the right to deregister or transfer the title if it does not meet the standards of the Coordinating Group and/or Campbell.

You accept responsibility for maintaining the review in light of new evidence, comments and criticisms, and other developments, and updating the review at least once every 5 years, or, if requested, transferring responsibility for maintaining the review to others as agreed with the Coordinating Group.

Publication in the Campbell Library

The support of the Coordinating Group in preparing your review is conditional upon your agreement to publish the protocol, finished review, and subsequent updates in the Campbell Library. Campbell places no restrictions on publication of the findings of a Campbell systematic review in a more abbreviated form as a journal article either before or after the publication of the monograph version in Campbell Systematic Reviews. Some journals, however, have restrictions that preclude publication of findings that have been, or will be, reported elsewhere and authors considering publication in such a journal should be aware of possible conflict with publication of the monograph version in Campbell Systematic Reviews. Publication in a journal after publication or in press status in Campbell Systematic Reviews should acknowledge the Campbell version and include a citation to it. Note that systematic reviews published in Campbell Systematic Reviews and co-registered with Cochrane may have additional requirements or restrictions for co-publication. Review authors accept responsibility for meeting any co-publication requirements.

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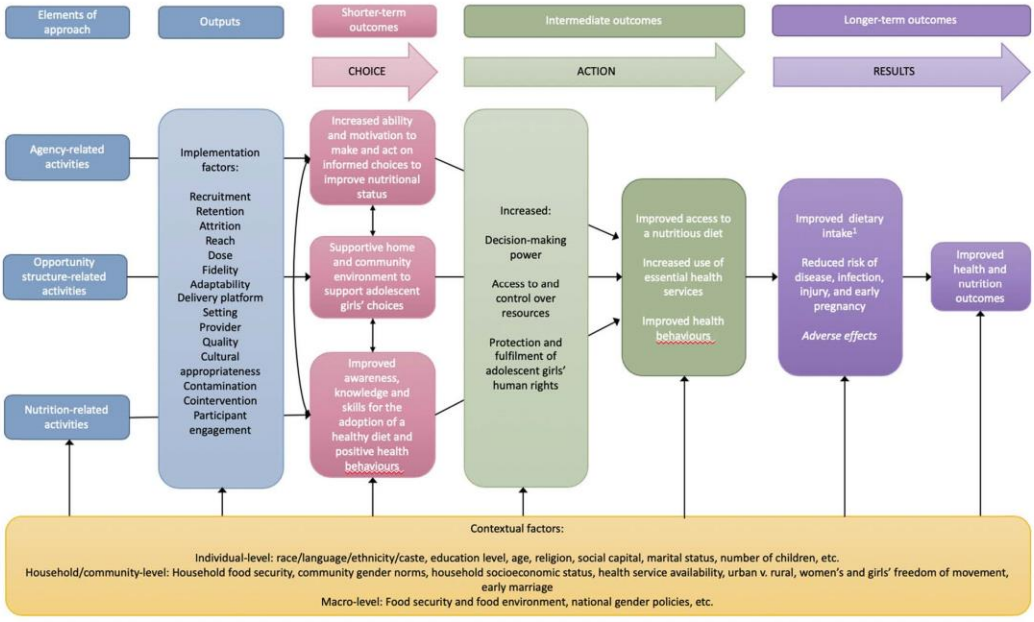
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APPENDIX A: LOGIC MODEL: EMPOWERMENT-BASED NUTRITION INTERVENTIONS TO IMPROVE ADOLESCENT GIRLS' NUTRITIONAL STATUS



APPENDIX B: MEDLINE SEARCH STRATEGY

1 " Power (Psychology)"/ (158608)
2 Attitude/ (107645)
3 Attitude to Health/ (190744)
4 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (41819)
5 Intention/ (171233)
6 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (8807)
7 Motivation/ (216063)
8 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (13802)
9 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kf. (14391)
10 Self Efficacy/ (92885)
11 Personal Autonomy/ (29331)
12 Self Concept/ (184924)
13 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw,kf. (2505725)
14 (abilit* adj3 (act or acted or acting or acts or action?)).tw,kf. (7288)
15 Women's Rights/ (15820)
16 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw,kf. (36459)
17 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw,kf. (74261)
18 (active$2 adj2 (engag* or involv* or participat*)).tw,kf. (61724)
19 participatory.tw,kf. (35824)
20 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw,kf. (21145)
21 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw,kf. (31601)
22 Gender Identity/ (41227)
23 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw,kf. (28904)

24 Social Norms/ (10338)
25 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw,kf. (36015)
26 or/1–25 (3571314)
27 Nutritional Requirements/ (37442)
28 Nutritional Status/ (105385)
29 Nutritive Value/ (30809)
30 Adolescent Nutritional Physiological Phenomena/ (1838)
31 Maternal Nutritional Physiological Phenomena/ (13721)
32 malnutrition/ (75398)
33 exp Deficiency Diseases/ (260675)
34 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw,kf. (8831)
35 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (4094)
36 scurvy.tw,kf. (4345)
37 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (1959)
38 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (7851)
39 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw,kf. (17888)
40 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw,kf. (15262)
41 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (1819)
42 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (2802)
43 pellagra.tw,kf. (2774)
44 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (3255)
45 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (7920)
46 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kf. (2773)
47 overnutrition/ (5853)
48 exp Obesity/ (711110)
49 growth Disorders/ (26038)
50 ((growth adj2 stunt$2) or stunting).tw,kf. (14027)
51 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw,kf. (1769168)
52 anemia/ (242868)
53 exp Anemia, Hypochromic/ (46742)
54 (an?emic or an?emia* or chloros#s).tw,kf. (387455)
55 Feeding Behavior/ (172106)
56 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw,kf. (141785)
57 diet/ (402699)
58 (diet or dieted or diets or dietary or dieting).tw,kf. (1174789)
59 energy Intake/ (93531)
60 ((calori* or energy or protein?) adj3 intak*).tw,kf. (115306)
61 healthy Diet/ (4701)
62 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw,kf. (39237)
63 exp Micronutrients/ (688381)
64 (micronutri* or micro-nutri*).tw,kf. (35383)
65 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw,kf. (44266)
66 Calcium, Dietary/ (31557)
67 Chromium/ (59565)
68 Copper/ (178475)
69 Iodine/ (75382)
70 Iron/ (259984)
71 Manganese/ (74289)
72 Molybdenum/ (21257)
73 Selenium/ (58025)
74 Zinc/ (170532)
75 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw,kf. (1924054)
76 vitamin*.tw,kf. (512331)
77 exp Dietary Supplements/ (89126)
78 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw,kf. (25906)
79 n?utr#ceutical?.tw,kf. (14005)
80 Food, Fortified/ (11093)
81 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw,kf. (25026)
82 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw,kf. (19850)
83 Food Supply/ (28920)
84 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw,kf. (31860)
85 or/27–84 (6032125)
86 26 and 85 (298093)
87 Developing Countries/ (159704)

88 Africa/ or Asia/ or Caribbean/ or West Indies/ or South America/ or Latin America/ or Central America/ (228463)

89 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).tw,kf. (2468939)

90 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)

91 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw,kf. (262888)

92 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw,kf. (3030)

93 (low* adj (gdp or gnp or gross domestic or gross national)).tw,kf. (641)

94 (low adj3 middle adj3 countr*).tw,kf. (31752)

95 (lmic or lmics or third world or lami countr*).tw,kf. (16026)

96 transitional countr*.tw,kf. (457)

97 or/87–96 (3718691)

98 86 and 97 (32745)

99 Women/ (8405706)

100 Pregnant Women/ (69649)

101 Female/ and (Adolescent/ or Adult/ or Young Adult/) (9600899)
102 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw,kf. (4328988)
103 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw,kf. (286629)
104 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw,kf. (28995)
105 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw,kf. (66012)
106 young girl?.tw,kf. (10028)
107 or/99–106 (15081858)
108 98 and 107 (19470)
109 exp Animals/ not Humans/ (17546303)
110 108 not 109 [ANIMAL-ONLY REMOVED] (13985)
111 (comment or editorial or news or newspaper article).pt. (1896536)
112 (letter not (letter and randomised controlled trial)).pt. (2072075)
113 110 not (111 or 112) [OPINION PIECES REMOVED] (13938)
114 113 use medall [MEDLINE RECORDS] (6474)
115 empowerment/ (27108)
116 attitude/ (107645)
117 attitude to health/ (190744)
118 attitude to life/ (657)
119 maternal attitude/ (2423)
120 attitude to pregnancy/ (580)
121 social attitude/ (2312)
122 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (45396)
123 behavior/ (209991)
124 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (9069)
125 motivation/ (216063)
126 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (14513)
127 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw,kw. (14391)
128 personal autonomy/ (29331)
129 exp self concept/ (373341)
130 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw,kw. (2512016)
131 (abilit* adj3 (act or acted or acting or acts or action?)).tw,kw. (7289)
132 women's rights/ (15820)
133 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw,kw. (36781)
134 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw,kw. (74297)
135 (active$2 adj2 (engag* or involv* or participat*)).tw,kw. (61734)
136 participatory*.tw,kw. (36423)
137 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw,kw. (21169)
138 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw,kw. (31657)
139 gender identity/ (41227)
140 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw,kw. (28723)
141 social norm/ (10891)
142 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw,kw. (36159)
143 or/115–142 (3718206)
144 nutrition/ (124564)
145 nutritional health/ (6190)
146 exp nutritional requirement/ (39461)
147 exp nutritional status/ (106035)
148 nutritional value/ (31912)
149 adolescent nutrition/ (202)
150 maternal nutrition/ (11173)
151 malnutrition/ (75398)
152 exp nutritional deficiency/ (283978)
153 exp protein deficiency/ (44783)
154 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw,kw. (8961)
155 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (4087)
156 scurvy.tw,kw. (4353)
157 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2055)
158 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (7851)
159 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw,kw. (17918)
160 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw,kw. (15531)

161 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (1816)
162 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2805)
163 pellagra.tw,kw. (2772)
164 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (3220)
165 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (7929)
166 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw,kw. (2690)
167 exp overnutrition/ (694990)
168 growth disorder/ (33286)
169 stunting/ (19313)
170 ((growth adj2 stunt$2) or stunting).tw,kw. (14278)
171 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw,kw. (1793960)
172 anemia/ (242868)
173 iron deficiency anemia/ (37358)
174 (an?emic or an?emia* or chloros#s).tw,kw. (395051)
175 eating habit/ (99906)
176 feeding behavior/ (172106)
177 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw,kw. (144241)
178 diet/ (402699)
179 (diet or dieted or diets or dietary or dieting).tw,kw. (1187821)
180 caloric intake/ (96310)
181 ((calori* or energy or protein?) adj3 intak*).tw,kw. (117328)
182 dietary intake/ (73687)
183 healthy diet/ (4701)
184 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw,kw. (39335)
185 exp nutrient/ (677172)
186 nutrient availability/ (3222)
187 nutrient content/ (5017)
188 nutrient limitation/ (1029)
189 nutrient supply/ (2308)
190 nutrient uptake/ (2874)
191 (micronutri* or micro-nutri*).tw,kw. (36132)
192 exp trace element/ (366886)
193 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw,kw. (46036)
194 chromium/ (59565)
195 copper/ (178475)
196 iodine/ (75382)
197 manganese/ (74289)
198 molybdenum/ (21257)
199 selenium/ (58025)
200 zinc/ (170532)
201 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw,kw. (1949030)
202 vitamin/ (89429)
203 vitamin*.tw,kw. (522115)
204 dietary supplement/ (61637)
205 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw,kw. (26015)
206 nutraceutical/ (64077)
207 n?utr#ceutical?.tw,kw. (14562)
208 fortified food/ (11096)
209 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw,kw. (25657)
210 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw,kw. (20058)
211 food availability/ (3871)
212 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw,kw. (31599)
213 or/144–212 (6081563)
214 143 and 213 (313876)
215 developing country/ (165162)
216 (Africa or Asia or Caribbean or West Indies or South America or Latin America or Central America).hw,tw,kw. (640442)
217 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar

or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).hw,tw,kw. (3320872)

218 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)

219 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw,kw. (237596)

220 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw,kw. (3036)

221 (low* adj (gdp or gnp or gross domestic or gross national)).tw,kw. (645)

222 (low adj3 middle adj3 countr*).tw,kw. (31748)

223 (lmic or lmics or third world or lami countr*).tw,kw. (16181)

224 transitional countr*.tw,kw. (462)

225 or/215–224 (4044608)

226 214 and 225 (36165)

227 exp named groups by pregnancy/ (101747)

228 pregnant woman/ (82942)

229 female/ and (adult/ or young adult/ or juvenile/ or adolescent/ or adolescent parent/) (9605834)

230 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw,kw. (4340623)

231 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw,kw. (292884)

232 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw,kw. (28995)

233 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw,kw. (66013)

234 young girl?.tw,kw. (10038)

235 or/227–234 (12506222)

236 226 and 235 (20195)

237 exp animal/ or exp animal experimentation/ or exp animal model/ or exp animal experiment/ or nonhuman/ or exp vertebrate/ (50805119)

238 exp human/ or exp human experimentation/ or exp human experiment/ (38981083)

239 237 not 238 (11825722)

240 236 not 239 [ANIMAL-ONLY REMOVED] (20036)

241 editorial.pt. (1081172)

242 letter.pt. not (letter.pt. and randomised controlled trial/) (2071940)
243 240 not (241 or 242) [OPINION PIECES REMOVED] (19985)
244 243 use emczd [EMBASE RECORDS] (9903)
245 Social Identity/ (105394)
246 Group Identity/ (1322)
247 Attitudes/ (72109)
248 Community Attitudes/ (2559)
249 Death Attitudes/ (19039)
250 Eating Attitudes/ (1539)
251 Female Attitudes/ (1625)
252 Health Attitudes/ (94051)
253 exp Sex Role Attitudes/ (12044)
254 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (41335)
255 exp Intention/ (3953989)
256 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (8802)
257 Motivation/ (216063)
258 Expectations/ (81852)
259 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (13785)
260 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).tw. (14391)
261 Self-Efficacy/ (92885)
262 "Independence (Personality)"/ (4988)
263 Self-Determination/ (20619)
264 Self-Concept/ (184924)
265 Self-Confidence/ (57437)
266 Self-Esteem/ (101452)
267 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).tw. (2502151)
268 (abilit* adj3 (act or acted or acting or acts or action?)).tw. (7288)
269 Self-Perception/ (146381)
270 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).tw. (34478)
271 Involvement/ (6748)
272 Participation/ (7668)
273 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).tw. (74248)
274 (active$2 adj2 (engag* or involv* or participat*)).tw. (61718)
275 participatory*.tw. (35257)
276 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).tw. (21143)
277 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).tw. (31568)
278 Gender Equality/ (667)
279 Role Expectations/ (1621)
280 Sex Roles/ (34691)
281 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).tw. (28694)
282 Social Norms/ (10338)
283 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).tw. (35820)
284 or/245–283 (6964179)
285 Nutrition/ (124564)
286 exp Nutritional Deficiencies/ (124075)
287 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#s).tw. (8621)
288 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (3989)
289 scurvy.tw. (3901)
290 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (1959)
291 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (7797)
292 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).tw. (17757)
293 (hyperhomocystein?emi* or hyper-homocystein?emi*).tw. (15197)
294 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (1792)
295 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (2784)
296 pellagra.tw. (2584)
297 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (3196)
298 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (7817)
299 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).tw. (2639)
300 Obesity/ (598386)
301 ((growth adj2 stunt$2) or stunting).tw. (13942)
302 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or

overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).tw. (1748835)
303 Anemia/ (242868)
304 (an?emic or an?emia* or chloros#s).tw. (380030)
305 Eating Behavior/ (174683)
306 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).tw. (141008)
307 Diets/ (161532)
308 (diet or dieted or diets or dietary or dieting).tw. (1165001)
309 Food Intake/ (184009)
310 ((calori* or energy or protein?) adj3 intak*).tw. (115118)
311 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).tw. (39122)
312 (micronutri* or micro-nutri*).tw. (35029)
313 Metallic Elements/ (436)
314 (trace element? or trace mineral? or micromineral? or micro-mineral?).tw. (43646)
315 exp Calcium/ (570689)
316 Copper/ (178475)
317 Iron/ (259984)
318 Zinc/ (170532)
319 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).tw. (1900718)
320 Vitamins/ (89507)
321 vitamin*.tw. (499855)
322 Dietary Supplements/ (67852)
323 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).tw. (25555)
324 n?utr#ceutical?.tw. (13721)
325 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).tw. (24593)
326 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).tw. (19806)
327 Food Deprivation/ (18608)
328 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).tw. (30873)
329 or/285–328 (5847359)
330 284 and 329 (656017)
331 Developing Countries/ (159704)
332 (Africa? or Asia? or Caribbean or West Indies or South America? or Latin America? or Central America?).tw. (924816)
333 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).tw. (2449161)
334 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).tw. (233745)
335 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or poor*) adj econom*).tw. (3024)
336 (low* adj (gdp or gnp or gross domestic or gross national)).tw. (641)
337 (low adj3 middle adj3 countr*).tw. (31256)
338 (lmic or lmics or third world or lami countr*).tw. (15802)
339 transitional countr*.tw. (456)
340 or/331–339 (3253265)
341 330 and 340 (74884)
342 Adolescent Mothers/ (2282)
343 Expectant Mothers/ (637)
344 (woman* or women* or matern* or mother* or wife or wives or pregnan*).tw. (4311022)

345 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).tw. (285627)

346 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).tw. (28995)

347 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).tw. (66012)

348 young girl?.tw. (10026)

349 or/342–348 (4596550)

350 Human Females/ (88344)

351 Wives/ (13136)

352 350 or 351 (101298)

353 limit 352 to (200 adolescence <age 13 to 17 yrs> or 320 young adulthood <age 18 to 29 yrs> or 340 thirties <age 30 to 39 yrs> or 360 middle age <age 40 to 64 yrs>) [Limit not valid in Embase,Ovid MEDLINE(R),Ovid MEDLINE(R) Daily Update,Ovid MEDLINE(R) In-Process,Ovid MEDLINE(R) Publisher,CCTR,CDSR,DARE,CLHTA,-CLEED; records were retained] (43270)

354 349 or 353 (4605043)

355 341 and 354 (27908)

356 355 use medall,emczd,cctr,coch,dare,clhta,cleed (26667)

357 355 not 356 [PSYCINFO RECORDS] (1241)

358 "Power (Psychology)"/ (158608)

359 Attitude/ (107645)

360 Attitude to Health/ (190744)

361 ((attitud* or opinion*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (42279)

362 Intention/ (171233)

363 ((intention? or intent? or intend*) adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (8886)

364 Motivation/ (216063)

365 (motivat* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (14263)

366 (encourag* adj3 (diet* or eating or feeding or food? or health* or malnutrit* or malnourish* or meal? or nutrient? or nutrition or nutritive or snack?)).ti,ab,kw. (14226)

367 Self Efficacy/ (92885)

368 Personal Autonomy/ (29331)

369 Self Concept/ (184924)

370 (capable or capabilit* or emancipat* or empower* or agency or self-efficac* or power* or autonomy or (self adj2 determin*) or (self adj2 concept*) or (self adj2 confiden*) or (self adj2 percept*) or (self adj2 esteem)).ti,ab,kw. (2484054)

371 (abilit* adj3 (act or acted or acting or acts or action?)).ti,ab,kw. (7236)

372 Women's Rights/ (15820)

373 ((wom#n* adj2 right?) or (wom#n* adj2 status*) or (girl* adj2 right?) or (girl* adj2 status*) or (female? adj2 right?) or (female? adj2 status*) or (wife adj2 right?) or (wife adj2 status*) or (mother* adj2 right?) or (mother* adj2 status*) or (wives adj2 right?) or (wives adj2 status*)).ti,ab,kw. (36005)

374 ((wom#n* or girl* or female? or mother* or wife or wives) adj2 (engag* or involv* or participat*)).ti,ab,kw. (73351)

375 (active$2 adj2 (engag* or involv* or participat*)).ti,ab,kw. (61322)

376 participatory*.ti,ab,kw. (35693)

377 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 (advoca* or input* or ombuds* or represent*)).ti,ab,kw. (20803)

378 ((citizen* or communit* or gender* or public or village?) adj3 (advoca* or input* or ombuds* or represent*)).ti,ab,kw. (31346)

379 Gender Identity/ (41227)

380 ((wom#n* or girl* or female? or mother* or wife or wives) adj3 role?).ti,ab,kw. (27434)

381 Social Norms/ (10338)

382 ((social* or societ* or cultural* or group?) adj3 (custom* or norm?)).ti,ab,kw. (34970)

383 or/358–382 (3552165)

384 Nutritional Requirements/ (37442)

385 Nutritional Status/ (105385)

386 Nutritive Value/ (30809)

387 Adolescent Nutritional Physiological Phenomena/ (1838)

388 Maternal Nutritional Physiological Phenomena/ (13721)

389 Malnutrition/ (75398)

390 exp Deficiency Diseases/ (260675)

391 (avitaminos#s or hypovitaminos#s or hypo-vitaminos#-s).ti,ab,kw. (8948)

392 ((ascorbic acid? or ferrous ascorbate or hybrin or magnesium ascorbate or magnesium ascorbicum or magnesium di-L-ascorbate or magnorbin or sodium ascorbate) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (4074)

393 scurvy.ti,ab,kw. (4341)

394 ((all-trans-retinol or aquasol a or retinol) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2037)

395 ((bursine or choline or fagine or vagine) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (7843)

396 ((folacin or folate or folic acid? or folvite or IFA or pteroylglutamic acid?) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack*or supplement*)).ti,ab,kw. (17838)

397 (hyperhomocystein?emi* or hyper-homocystein?emi*).ti,ab,kw. (15508)

398 ((niacin? or enduracin or induracin or lithium nicotinate or nicamin or nico-400 or nicobid or nicocap or nicolar or nicotinate or nicotinic acid? or wampocap) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (1808)

399 ((tryptophan or ardeydorm or ardeytropin or L-tryptophan or levotryptophan or lyphan or naturruhe or optimax or pms-tryptophan or trofan or tryptacin or tryptan or ratio-tryptophan) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2791)
400 pellagra.ti,ab,kw. (2759)
401 (riboflavin? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (3214)
402 ((thiamine? or aneurin or thiamin) adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (7904)
403 (pyridoxine? adj3 (deficien* or deficit? or inadequa* or insufficien* or intak* or lack* or supplement*)).ti,ab,kw. (2684)
404 Overnutrition/ (5853)
405 exp Obesity/ (711110)
406 Growth Disorders/ (26038)
407 ((growth adj2 stunt$2) or stunting).ti,ab,kw. (14204)
408 (nutrient? or nutrition* or nutritive or nourish* or malnutrit* or malnourish* or undernutrition or undernourish* or overnutrition or overnourish* or obese or obesity or wasting or underweight or under weight or overweight or over weight).ti,ab,kw. (1787088)
409 Anemia/ (242868)
410 exp Anemia, Hypochromic/ (46742)
411 (an?emic or an?emia* or chloros#s).ti,ab,kw. (393916)
412 Feeding Behavior/ (172106)
413 ((eating or feeding or food or meal? or snack*) adj3 (behavio?r* or habit? or habitual* or pattern* or practice?)).ti,ab,kw. (141188)
414 Diet/ (402699)
415 (diet or dieted or diets or dietary or dieting).ti,ab,kw. (1184491)
416 Energy Intake/ (93531)
417 ((calori* or energy or protein?) adj3 intak*).ti,ab,kw. (116855)
418 Healthy Diet/ (4701)
419 ((eating or feeding or food? or meal? or snack*) adj3 (healthy or unhealthy)).ti,ab,kw. (39049)
420 exp Micronutrients/ (688381)
421 (micronutri* or micro-nutri*).ti,ab,kw. (35918)
422 (trace element? or trace mineral? or micromineral? or micro-mineral?).ti,ab,kw. (45946)
423 Calcium, Dietary/ (31557)
424 Chromium/ (59565)
425 Copper/ (178475)
426 Iodine/ (75382)
427 Iron/ (259984)
428 Manganese/ (74289)
429 Molybdenum/ (21257)
430 Selenium/ (58025)
431 Zinc/ (170532)
432 (calcium or chromium or copper or fluoride or iodine or iron or manganese or molybdenum or selenium or zinc).ti,ab,kw. (1944286)
433 vitamin*.ti,ab,kw. (520663)
434 exp Dietary Supplements/ (89126)
435 ((eating or feeding or food? or meal? or snack*) adj3 supplement*).ti,ab,kw. (25760)
436 n?utr#ceutical?.ti,ab,kw. (14503)
437 Food, Fortified/ (11093)
438 ((fortif* or enrich* or functional) adj2 (eating or feeding or food? or meal? or snack*)).ti,ab,kw. (25516)
439 ((home? or school* or work*) adj2 (ate or eaten or eating or eats or breakfast* or lunch* or dinner* or supper* or feed* or food? or meal?)).ti,ab,kw. (19800)
440 Food Supply/ (28920)
441 ((eating or feeding or food? or meal? or snack*) adj3 (secure* or securit* or insecure* or insecurit* or supply* or supplie*)).ti,ab,kw. (31461)
442 or/384–441 (6067800)
443 383 and 442 (295635)
444 Developing Countries/ (159704)
445 Africa/ or Asia/ or Caribbean/ or West Indies/ or South America/ or Latin America/ or Central America/ (228463)
446 (Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Cuba or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or Netherlands Antilles or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Papua New Guinea or Romania or Rumania or Roumania or Rwanda or Ruanda or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Senegal or Serbia or

Montenegro or Seychelles or Sierra Leone or Sri Lanka or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or South Africa or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).ti,ab,kw. (2446958)

447 exp africa/ or exp africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or tunisia/ or exp "africa south of the sahara"/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or south sudan/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/ or americas/ or exp caribbean region/ or exp west indies/ or exp central america/ or belize/ or costa rica/ or el salvador/ or guatemala/ or honduras/ or nicaragua/ or panama/ or panama canal zone/ or latin america/ or mexico/ or exp south america/ or argentina/ or bolivia/ or brazil/ or chile/ or colombia/ or ecuador/ or french guiana/ or guyana/ or paraguay/ or peru/ or suriname/ or uruguay/ or venezuela/ or asia/ or asia, central/ or kazakhstan/ or kyrgyzstan/ or tajikistan/ or turkmenistan/ or uzbekistan/ or exp asia, southeastern/ or borneo/ or brunei/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or mekong valley/ or myanmar/ or philippines/ or singapore/ or thailand/ or vietnam/ or asia, western/ or bangladesh/ or bhutan/ or india/ or sikkim/ or middle east/ or afghanistan/ or bahrain/ or iran/ or iraq/ or israel/ or jordan/ or kuwait/ or lebanon/ or oman/ or qatar/ or saudi arabia/ or syria/ or turkey/ or united arab emirates/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or far east/ or china/ or beijing/ or macau/ or tibet/ or korea/ or mongolia/ or taiwan/ or indian ocean islands/ or comoros/ or madagascar/ or mauritius/ or reunion/ or seychelles/ or pacific islands/ or exp melanesia/ or exp micronesia/ or polynesia/ or pitcairn island/ or exp samoa/ or tonga/ or prince edward island/ or west indies/ or "antigua and barbuda"/ or bahamas/ or barbados/ or cuba/ or dominica/ or dominican republic/ or grenada/ or guadeloupe/ or haiti/ or jamaica/ or martinique/ or netherlands antilles/ or puerto rico/ or "saint kitts and nevis"/ or saint lucia/ or "saint vincent and the grenadines"/ or "trinidad and tobago"/ or united states virgin islands/ or oceania/ (2424512)

448 ((developing or less* developed or under developed or under-developed or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or region? or world or state*)).ti,ab,kw. (234706)

449 ((developing or less* developed or under developed or under-developed or middle income or low* income or poor*) adj econom*).ti,ab,kw. (2988)

450 (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab,kw. (643)

451 (low adj3 middle adj3 countr*).ti,ab,kw. (30878)

452 (lmic or lmics or third world or lami countr*).ti,ab,kw. (15985)

453 transitional countr*.ti,ab,kw. (445)

454 or/444–453 (3687965)

455 443 and 454 (30919)

456 Women/ (8405706)

457 Pregnant Women/ (69649)

458 Female/ and (Adolescent/ or Adult/ or Young Adult/) (9600899)

459 (woman* or women* or matern* or mother* or wife or wives or pregnan*).ti,ab,kw. (4324318)

460 ((female? or girl*) adj5 (adolescen* or adult* or child-bearing or childbearing or highschool* or school* or teen* or marry* or marriage* or marrie? or menstru* or post-pubescen* or postpubescen* or post-puberty or postpuberty or reproductive or spous* or youth* or young adult?)).ti,ab,kw. (284320)

461 ((female? or girl or girls) adj2 (ten year? or ten yr? or 10 year? or 10 yr? or eleven year? or eleven yr? or 11 year? or 11 yr? or twelve year? or twelve yr? or 12 year? or 12 yr?)).ti,ab,kw. (28338)

462 ((female? or girl or girls) adj2 (age? or old) adj3 ("10" or ten or "11" or eleven or "12" or twelve)).ti,ab,kw. (65402)

463 young girl?.ti,ab,kw. (9994)

464 or/456–463 (15074516)

465 455 and 464 (18238)

466 465 use coch,cctr,dare,clhta,cleed [COCHRANE RECORDS] (925)

467 114 or 244 or 357 or 466 [ALL DATABASES] (18543)

468 limit 467 to "yr=2016-current" [Limit not valid in DARE; records were retained] (5061)

469 remove duplicates from 468 (3740)

470 limit 467 to "yr=2011–2015" [Limit not valid in DARE; records were retained] (5957)

471 remove duplicates from 470 (4296)

472 limit 467 to yr="2000–2010" [Limit not valid in DARE; records were retained] (4760)

473 remove duplicates from 472 (3258)

474 467 not (468 or 470 or 472) (2767)

475 remove duplicates from 474 (2200)

476 469 or 471 or 473 or 475 [TOTAL UNIQUE RECORDS] (13492)

477 476 use medall [MEDLINE UNIQUE RECORDS] (6468)

478 476 use emczd [EMBASE UNIQUE RECORDS] (5659)

479 476 use medal, emczd, coch, cctr, dare, cleed, clhta (12605)

480 476 not 479 [PSYCINFO UNIQUE RECORDS] (887)

481 476 use coch [DSR UNIQUE RECORDS] (4)

482 476 use dare [DARE UNIQUE RECORDS] (1)

483 476 use cleed [NHS UNIQUE RECORDS] (0)

484 476 use clhta [HTA UNIQUE RECORDS] (0)

485 476 use CCTR [CENTRAL UNIQUE RECORDS] (473)

APPENDIX C: DATA EXTRACTION CODE BOOKS

Quantitative Study Codebook

Where possible, provide direct quotes and page numbers to support your extractions.

Code	Description
Study ID	From Covidence
Date coded	
Coder initials	
Correspondence required	Add a note here if authors will need to be contacted to request additional information
Reference identification	
Title	
First author	
Year	
Type of publication	(drop-down) Journal article / Book / Conference abstract / Dissertation / Report / Other
Other	Define "other" publication type
Funder	
Country	
City and region (if applicable)	
Start date of study	
End date of study	
Study duration	
Aim of the study	
Authors' definition of empowerment	
Authors' rationale for empowerment approach	
Methods	
Study design	(drop-down) RCT / cRCT / CBA / ITS / DID / RDD / PSM / other
Other	Define "other" study design type
Study design description	
Comparison group	Describe the nature of the comparison group
Statistical method	Describe method used and comment on appropriateness.
Intervention	
Number of treatment arms	(drop-down) 1–10
Description of treatment arm 1	
Description of treatment arm 2 (continue adding as needed)	
Type of nutrition intervention	(drop-down–select all that apply) Micronutrient supplementation / Fortification / Education or Counselling / School feeding / Other supplemental nutrition / Other
Description of nutrition intervention	
Type of agency intervention	(drop-down–select all that apply) Mentorship program / Leadership skills training / Technical or occupational skills training / Program leadership role for girls / Peer education / Peer support group / Other
Description of agency intervention	
Type of opportunity structure intervention	(drop-down—select all that apply) Cash transfer program / Savings and loan program / Education support / Girls' rights advocacy or education (with parents, teachers, community influencers) / Prevention of early marriage and pregnancy / Other
Description of opportunity structure intervention	
Intervention setting	(drop-down – select all that apply) School / Community / Home / Health Facility / Other
Other	Describe "other" intervention setting
Geography	(drop-down – select all that apply) Urban / Rural / Remote / Slum / Other
Other	Describe other geographic setting
Intervention administrator	(drop-down) Foreign government / local or national government / non-government organization / community-based organization / Academic institution / Other
Other	Describe other intervention administrator

(Continues)

Intervention provider	(drop-down – select all that apply) Community health workers / Health facility staff / Teachers / Peers / Parents / Volunteers / Other
Other	Describe other intervention provider
Provider training	Describe the training of providers to deliver intervention
Recruitment	Describe procedures for recruiting participants
Attrition rate	The proportion of participants lost during the intervention or during follow-up.
Reach	Describe the degree to which the intended audience participated in an intervention by "their presence"
Dose	Describe the proportion or amount of an intervention delivered to participants. E.g., measures of frequency, duration, and/or intensity
Fidelity / integrity	Describe the degree to which the intervention was delivered as intended.
Adaptation	Describe the degree to which the program content was intentionally changed during implementation to improve programme effectiveness
Prior needs assessment	Describe any needs assessment that was conducted to inform intervention design
Reminders	Describe any prompts or reminders sent to participants to attend / participate in intervention
Quality	Describe any findings related to the quality of quality of intervention materials/ resources (e.g., curriculum, training, and policy)
Cultural appropriateness	Describe any findings related to the cultural appropriateness of the intervention
Contamination	Describe any unintentional delivery of intervention to the control group or inadvertent failure to deliver intervention to experimental group
Cointervention	Describe any instances where interventions other than the treatment were applied differently to intervention conditions
Participant engagement	Describe participant's interaction with or receptivity to the intervention (i.e., what they think or how they feel about the intervention)
Contextual factors	Describe any social, built, and political factors internal (e.g., partnerships) and external to the intervention environment (e.g., social norms) that shape implementation.
Study population	
Number of participants	
Number in intervention group	
Number in comparison group	
Age range of study participants	Enter age range of study target population, e.g. 15–49 years
Age range of adolescent study participants	Enter age range for female adolescents who are included in study, e.g., 15–24 years
Age sub-groups	List all age sub-groups for which data are provided, e.g. study covers 15–49 years, and analyses were done separately for 15–19 years, 20–24 years, 25–49 years
Did the study population also include men or boys?	(drop-down) Yes / No / Unclear
Adolescent participants' school status	(drop-down) In school / out of school / Both / Unclear
Race / ethnicity / language	Describe
Religion	Describe
Socio-economic status	Describe
Disability, physical health	Describe
Includes pregnant participants	(drop-down) Yes / No / Unclear
Includes young mothers	(drop-down) Yes / No / Unclear
Conflict setting	(drop-down) Yes / No / Unclear
Food insecure setting	(drop-down) Yes / No / Unclear
Outcomes	
Primary outcomes	Define outcomes and how they are measured

(Continues)

Secondary outcomes	Define outcomes and how they are measured
Method of assessing outcomes	Describe methods for assessing outcome measures
Validity and reliability of outcomes measures	Describe primary authors' views on the validity and reliability of outcome measures
Follow-up of non-respondents	Describe the methods used to follow-up non-respondents
Timing of outcome assessment	Describe frequency of assessment, length of follow-up, etc.
Results	
Number of participants in Treatment Arm 1 (continue adding rows for each treatment arm)	
Number of participants in Treatment Arm 2 (continue adding rows for each treatment arm)	
Number of participants in comparison group	
For each outcome...	
Direction of effect	(drop-down) Effect favours treatment / Effect favours comparison / Effect favours neither / Cannot tell
Effect statistically significant?	(drop-down) Yes / No / Cannot tell
Treatment sample size	
Control sample size	
Number of missing participants	
Nature of the measure	(drop-down) Continuous / Dichotomous / Other
If outcome measure is continuous...	
Treatment group mean	
Comparison group mean	
Are reported means adjusted?	(drop-down) Yes / No / Cannot tell
Treatment group standard deviation	
Comparison group standard deviation	
Treatment group standard error	
Comparison group standard error	
t-value for an independent *t*-test	
If outcome measure is dichotomous...	
Treatment group number of participants who experienced a change	
Comparison group number of participants who experienced a change	
Treatment group proportion of participants who experienced a change	
Comparison group proportion of participants who experienced a change	
Are the proportions adjusted for pretest variables?	
Logged odds ratio	
Standard error of logged odds ratio	
Adjusted logged odds ratio	
Chi-square with degrees of freedom	
Correlation coefficient	
Adverse events	
Adverse events	List all adverse events of integrating women's empowerment, as described by primary authors.

Qualitative study codebook.

Code	Description
Study ID	from Covidence
Date coded	
Coder initials	
Correspondence required	Add a note here if authors will need to be contacted to request additional information
Reference identification	
Title	
First author	
Year	
Type of publication	(drop-down) Journal article / Book / Conference abstract / Dissertation / Report / Other

Other	Define "other" publication type
Funder	
Country	
City and region (if applicable)	
Start date of study	
End date of study	
Aim of the study	
Authors' definition of empowerment	
Authors' rationale for empowerment approach	
Methods	
Study design description	
Study duration	
Participant inclusion/exclusion criteria	
Quality assessment (CASP)	
Was there a clear statement of the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Is a qualitative methodology appropriate?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the research design appropriate to address the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the recruitment strategy appropriate to the aims of the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the data collected in a way that addressed the research issue?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Has the relationship between researcher and participants been adequately considered?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Have ethical issues been taken into consideration?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Was the data analysis sufficiently rigorous?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Is there a clear statement of findings?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
How valuable is the research?	(drop-down) Yes / No / Unclear
Support for judgement (incl. pg #)	
Study population	
Number of participants	
Study scale	Small (e.g., one/several village) / large (e.g., district, region, province)
Describe scale	
Study setting	(drop-down) Urban / Rural / Informal-urban / Remote / Other
Describe setting	
Target	(drop-down) Individual / Household / Community / Other
Describe target	
Age range of study participants	Enter age range of study target population, e.g. 15–49 years
Adolescent age range	Enter age range for female adolescents who are included in study, e.g., 15–24 years
Age subgroups	List all female age sub-groups for which data are provided, e.g. study covers 15–49 years, and analyses were done separately for 15–19 years, 20–24 years, 25–49 years
Did the study population also include men or boys?	(drop-down) Yes / No / Unclear
Adolescent participants' school status	(drop-down) In school / out of school / Both / Unclear
Race / ethnicity / language	Describe
Religion	Describe
Socio-economic status	Describe
Disability, physical health	Describe
Includes pregnant participants	(drop-down) Yes / No / Unclear
Includes young mothers	(drop-down) Yes / No / Unclear

(Continues)

Conflict setting	(drop-down) Yes / No / Unclear
Food insecure setting	(drop-down) Yes / No / Unclear
Intervention	
Type of nutrition intervention	(drop-down – select all that apply) Micronutrient supplementation / Fortification / Education or Counselling / School feeding / Other supplemental nutrition / Other
Description of nutrition intervention	
Type of agency intervention	(drop-down – select all that apply) Mentorship program / Leadership skills training / Technical or occupational skills training / Program leadership role for girls / Peer education / Peer support group / Other
Description of agency intervention	
Type of opportunity structure intervention	(drop-down – select all that apply) Cash transfer program / Savings and loan program / Education support / Girls' rights advocacy or education (with parents, teachers, community influencers) / Prevention of early marriage and pregnancy / Other
Description of opportunity structure intervention	
Intervention setting	(drop-down – select all that apply) School / Community / Home / Health Facility / Other
Describe intervention setting	
Intervention administrator	(drop-down) Foreign government / local or national government / non-government organization / community-based organization / Academic institution / Other
Describe intervention administrator	
Intervention provider	(drop-down – select all that apply) Community health workers / Health facility staff / Teachers / Peers / Parents / Volunteers / Other
Describe intervention provider	
Provider training	Describe the training of providers to deliver intervention
Recruitment	Describe procedures for recruiting participants
Attrition rate	The proportion of participants lost during the intervention or during follow-up.
Reach	Describe the degree to which the intended audience participated in an intervention by "their presence"
Dose	Describe the proportion or amount of an intervention delivered to participants. E.g., measures of frequency, duration, and/or intensity
Fidelity / integrity	Describe the degree to which the intervention was delivered as intended.
Adaptation	Describe the degree to which the program content was intentionally changed during implementation to improve programme effectiveness
Prior needs assessment	Describe any needs assessment that was conducted to inform intervention design
Reminders	Describe any prompts or reminders sent to participants to attend / participate in intervention
Quality	Describe any findings related to the quality of quality of intervention materials/ resources (e.g., curriculum, training, and policy)
Cultural appropriateness	Describe any findings related to the cultural appropriateness of the intervention
Contamination	Describe any unintentional delivery of intervention to the control group or inadvertent failure to deliver intervention to experimental group
Cointervention	Describe any instances where interventions other than the treatment were applied differently to intervention conditions
Participant engagement	Describe participant's interaction with or receptivity to the intervention (i.e., what they think or how they feel about the intervention)

(Continues)

Contextual factors	Describe any social, built, and political factors internal (e.g., partnerships) and external to the intervention environment (e.g., social norms) that shape implementation.
Measures	
Feasibility (the extent to which an intervention is practical or viable in a particular context or situation)	
Cultural sensitivity of program	
Participant engagement	
Community/public commitment	
Appropriateness (the extent to which an intervention or activity fits with a particular context or situation)	
Participants' views on programme acceptability	
Implementers' views on programme acceptability	
Community support for programme	
Meaningfulness (the extent to which an intervention or activity is positively experienced by an individual or group)	
Participants' views on programme as a positive or negative experience	
Participants' views on benefits and costs of participation	
Participants' awareness of own nutritional needs	
Participants' motivation to act for improved nutrition	
Community desire to support participants to act for improved nutrition	
Adverse events	
Adverse events	List all adverse events of integrating women's empowerment, as described by primary authors.

(Continues)

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Associations between dimensions of empowerment and nutritional status among married adolescent girls in East Africa: a structural equation modelling study

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Abstract

Background Empowering adolescent girls is an important component of combating malnutrition in this age group. Because empowerment is multidimensional and context specific, it can be difficult for policymakers and practitioners to target the dimensions of empowerment associated with adolescent girls' nutrition in a particular setting. This study sought to identify the empowerment dimensions significantly associated with married adolescent girls' nutritional status in East Africa; a region where malnutrition and gender inequality stubbornly persist.

Methods We used cross-sectional Demographic and Health Survey (DHS) data from Ethiopia (2016), Kenya (2014), Tanzania (2015–16) and Uganda (2016) to construct and test theoretically informed structural equation models of the relationship between six dimensions of empowerment and BMI-for-age and haemoglobin levels for married adolescent girls aged 15–19 years.

Results Our models were found to be a good fit for the data. Married adolescent girls' access to information, measured by their education level and mass media use, was directly and positively associated with their BMI-for-age ($p < 0.05$). Asset ownership, measured by owning a house or land alone or jointly, was directly and positively associated with haemoglobin ($p < 0.05$) and reduced odds of being moderately to severely anemic. Rejecting justifications for intimate partner violence, a measure of respondents' intrinsic agency, was directly and positively associated with the odds of being overweight or obese. Adolescent girls' level of empowerment across all dimensions had a direct relationship with their country of residence and household wealth.

Conclusions Our findings suggest that investment in girls' access to information through education and mass/social media and their economic empowerment may be important contributors to their overall empowerment and nutritional status. However, caution is needed as greater autonomy may contribute to increased consumption of unhealthy foods that can contribute to overweight and obesity. Strategies to empower married adolescent girls should be tailored to their specific circumstances. There is an urgent need for better data on adolescent empowerment and health, including increased research into age-, sex- and gender-appropriate empowerment measures and

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longitudinal data to assess causality. The use of statistical models should be complemented by robust qualitative research to further results interpretation.

Keywords Adolescent Girls, Adolescent Nutrition, Adolescent Empowerment, East Africa, Structural Equation Models

Background

Late adolescence, from the ages of 15 to 19 years, is a time of important physiological growth and neurodevelopment for girls that can be undermined by poor nutrition. Bone acquisition continues into late adolescence, with final bone mineral content plateauing in girls at around 18 years [1]. Undernutrition in late adolescence can have negative consequences on brain development while chronic malnutrition increases the risk of adiposity and non-communicable diseases later in life [1]. Adolescent pregnancy has several negative consequences for adolescent girls' health and contributes to an intergenerational cycle of malnutrition [2].

East Africa is a region where progress on addressing malnutrition among adolescent girls is slow. In the last decade, thinness (BMI-for-age (ZBFA) < -2 standard deviations (SD)) among girls aged 5–19 years in East Africa declined only 0.5 to 4.6%, while the prevalence of overweight and obesity (ZBFA > 1 SD) increased from 5.5 to 17.3% over the same period [3]. Approximately 32% of all women and girls aged 15–49 years in the region are anemic [3].

Sex- and gender-related disparities in nutrition are a consequence of physiological and sociocultural factors. Iron-deficiency anemia affects both sexes, but adolescent girls carry the greatest burden due to the additional iron requirements that come with the onset of menarche. Boys acquire more lean body mass during adolescence while girls accrue more fat body mass, contributing to higher rates of thinness in boys and overweight and obesity in girls [1]. Early and child marriage contributes to adolescent pregnancy which accounts for over 10% of global total births annually [4]. The competition for nutrients between the still growing mother and the fetus restricts maternal growth and increases the risk of preterm delivery, low birthweight, and small-for-gestational age among neonates [5]. Son preference in families results in many girls eating last, least, and of lesser quality compared to boys and men in the household [6]. It also de-prioritizes their timely access to healthcare needed to prevent disease and unplanned pregnancy.

The drivers of malnutrition among adolescents are multifactorial. Individual behaviours such as food choice, dietary intake and physical activity are influenced by the food environment which is shaped by household and community dietary and activity patterns, economic development, urbanization and food and agriculture systems [7]. Gender inequality and restrictive gender norms play an important role in shaping these socio-ecological systems and disproportionately contribute to women and girls' poor health [7, 8]. Rigid gender norms are absorbed as early as age 10, coinciding with a shift in boys and girls' roles in the family and community on gendered lines [9]. For girls, this often means a decline in their agency and autonomy relative to boys, yet agency, or their ability to define and achieve goals, is critical to adolescent well-being [10]. The empowerment of adolescent girls is an important component of combating malnutrition in this age group [11–13]. Empowering married adolescent girls may require special attention compared to adult women. This group can face additional challenges to their agency and autonomy due to their relatively young age and lower status in the household. Younger age at marriage is associated with decreased bargaining power in the household [14]. Large age gaps between child brides and their husbands further disempower adolescent girls in the household hierarchy [15]. Married adolescent girls are more likely to become pregnant and prematurely leave school, stunting their learning and limiting their economic prospects [16]. Child marriage itself is a disempowering action and a human rights violation as girls often have little say in the decision of when and who to marry [17].

Empowerment is a complex construct that is multidimensional and context specific. As such, it can be difficult for policy makers and practitioners to identify and target the dimensions of empowerment that may positively influence adolescent girls' nutrition in a particular setting. A recent systematic review of women's empowerment measures in developing countries found the most common dimensions measured were household decision making, financial and economic decision making, freedom of movement, self-esteem, and sexual and reproductive decision making [18]. Further, there is evidence that different dimensions of women's empowerment influence maternal and child nutrition differently [19–22]. We hypothesized that a similar phenomenon exists for married girls in late adolescence, but there may be differences as to which empowerment dimensions are significant given this population's particular nutritional and empowerment-related challenges. Compared to adult women, the relationship between married adolescent girls' empowerment and their nutritional status is understudied. As such, the objective of this study was to model the relationship between dimensions of married adolescent

girls' empowerment and their nutritional status using cross-sectional Demographic and Health Survey data from four East African countries (Ethiopia, Kenya, Tanzania, and Uganda).

Methods

Conceptualizing empowerment

Empowerment refers to "the process by which those who have been denied the ability to make strategic life choices acquire such an ability" [23]. It involves a progression from a position of lacking choice, to once in which choice is exercised. Most importantly, it reflects *agency*, or the "ability to define one's goals and act upon them," in important life areas [23]. Decisions regarding strategic life choices have long term consequences for a person's life course and well-being, such as those regarding their education, reproductive health, and economic prospects. Agency over strategic life choices contributes to the realization and protection of individuals' human rights.

Empowerment is a complex and multidimensional construct. People can be empowered or disempowered in different area of their lives, which we term, *dimensions*. For example, a married adolescent girl may have the ability to choose what food is cooked daily, but she may not make decisions regarding contraceptive use. The ability to make strategic life choices across different dimensions reflects a person's *capabilities*. Capabilities are ways of 'doing or being,' or what people are actually able to be or do in different life areas that are important to them [24, 25].

A person's ability to access and control resources is crucial to the empowerment process. Kabeer identifies resources as necessary preconditions to the exercise of agency [23]. Resources are defined broadly to encompass not only economic or financial resources, such as earning an income or owning assets, but also human and social capital, time, and information. The more disempowered an individual, the greater likelihood that they have limited resources at their disposal. An individual's access to resources is shaped by their surrounding political, economic, legal, and socio-cultural environment. Alsop and Heinsohn (2005) define this concept as a person's *opportunity structure*, or the formal and informal institutions including laws, regulatory frameworks, and norms that define people's behaviours. They state that "[t]he presence and operation of the formal and informal laws, regulations, norms, and customs determine whether individuals and groups have access to assets, and whether these people can use the assets to achieve their desired outcomes" [26].

Our conceptual model (Fig. 1) brings together these components of empowerment to describe a process whereby agency, resources, and opportunity structure work together to create individual capabilities. These capabilities across different dimensions of empowerment are proposed to contribute to the achievement of an individual's goals. Specifically, our model theorizes that adolescent girls' capabilities across six empowerment dimensions have a direct influence on their nutritional status (Fig. 1). The dimensions are: (1) the ability to access information, (2) the ability to access healthcare, (3) the ability to make household decisions, (4) the ability to reject intimate partner violence, (4) the ability to own assets, and (6) the ability to exert social independence. The empowerment dimensions are measured (imperfectly) as latent constructs using observed indicators from the DHS. We reviewed existing studies (see Additional File 1) that modelled the nutrition-empowerment relationship using DHS data to identify indicators and empowerment dimensions to include in our model. We sought to identify indicators that measured not only the ability to make decisions (a direct measure of agency), but also measures of adolescent girls' access to resources and the existence of a supportive opportunity structure that would promote adolescent girls' agency and empowerment. Indicators selected for inclusion had to be (1) available across datasets with the percentage of missing data close to zero, (2) previously used as a measure of empowerment, (3) have sufficient variation to have adequate explanatory power, (4) be theoretically justified, and (5) contain no indicator correlations greater than 0.95 [27, 28]. Details on indicator coding and scales are available in Additional File 1.

Dimension 1: access to information

Access to information is necessary for adolescent girls to make informed decisions about their health and nutrition. We identified four relevant DHS indicators that we hypothesized would measure this construct. The first indicator was adolescent girls' level of completed education (measured in years). Education level is a strong predictor of health and nutrition among women and girls [29]. The remaining indicators measured respondents' use of mass media. The DHS asks respondents about the frequency in which they (1) watched television, (2) read the newspaper or magazine, and (3) listened to the radio. The use of mass media in behaviour change interventions has been shown to positively influence health-related knowledge and attitudes among adolescents and has the potential to positively shape gender norms alongside social media and technology [30, 31].

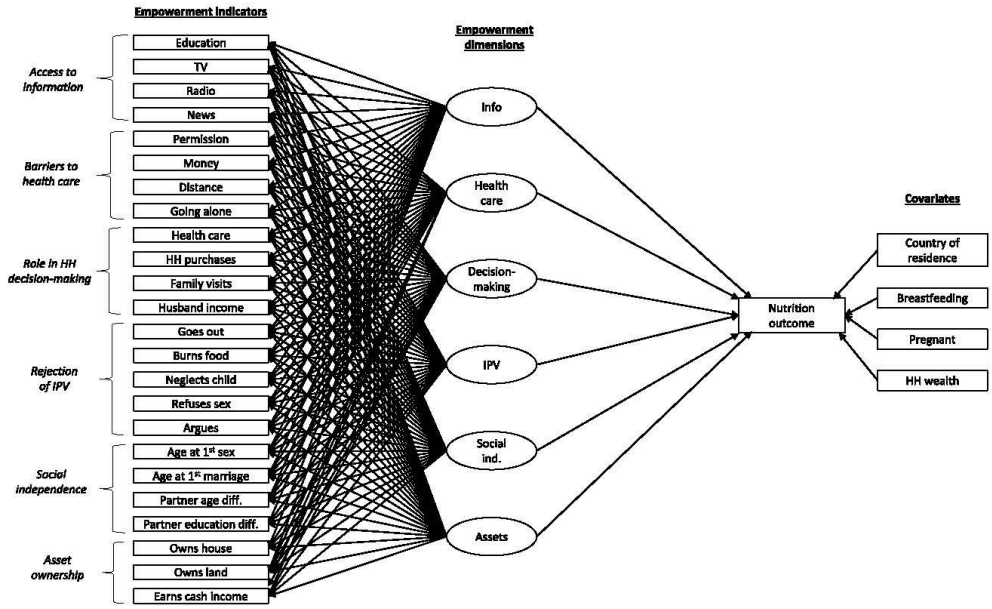


Fig. 1 Exploratory structural equation model of the relationship between dimensions of empowerment and nutrition status, controlling for important covariates. Notes: Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment dimensions). Unidirectional arrows represent direct effects of exposure on outcome. The lefthand side of the model is an exploratory factor analysis of empowerment indicators to define the underlying factor structure (empowerment dimensions). The righthand side of the model is a regression analysis of a nutritional outcome on empowerment dimensions. Both sides of the model are estimated simultaneously. Not shown: Error terms for estimated variables, covariance of factors

Dimension 2: access to healthcare

Adolescent girls can face various barriers to healthcare, many of which are linked to gender norms and inequality. Limited access to healthcare contributes to their increased risk of illness, disease, and unplanned pregnancy—all important contributors to malnutrition in this population. The DHS includes four variables to assess respondents' ability to access healthcare by asking them to indicate whether the following barriers to healthcare are "a big problem/not a big problem": (1) getting permission to go, (2) not wanting to go alone, (3) getting money for treatment, and (4) distance to the health facility.

Dimension 3: role in household decision-making

Decision-making power is frequently used as a measure of agency. The DHS includes four indicators to assess married respondents' level of participation in household decision-making (either not at all, alone, or jointly with their partner/other household member) in the following situations: (1) when the respondent wants to seek healthcare for themselves, (2) when they want to visit family or relatives, (3) when large household purchases are made, and (4) when decisions about their husband's income are made.

Dimension 4: rejecting IPV

Adolescent girls' views on intimate partner violence reflect the degree to which they have internalized harmful gender norms. Other studies have used these indicators to measure women's intrinsic agency [32–34]. The DHS asks respondents whether they agree (yes/no) that a husband is justified in beating his wife in the following scenarios: (1) when she neglects the children, (2) when she burns food, (3) when she refuses sex with her husband, (4) when she goes out without telling her husband, and (5) when she argues with her husband.

Dimension 5: asset ownership

Access to assets was hypothesized to capture respondents' financial autonomy and their ability to access and control financial resources. Three indicators were

included in this dimension: (1) whether the respondent owns a house either alone or jointly, (2) whether the respondent owns land either alone or jointly and (2) whether the respondent earns a cash income.

Dimension 6: social independence

The final dimension examined respondents' ability to counter negative social norms that disempower women and girls, such as child/early/forced marriage and adolescent pregnancy. It included (1) respondent's age at first cohabitation (a higher age was interpreted as greater empowerment) [35], (2) respondent's age at first sex (early sexual activity is often due to a lack of choice and further disempowers girls' when adolescent pregnancy leads to school dropouts) [36], (3) respondent's age difference with her partner (smaller gap = greater empowerment), and (4) her education level difference with her partner (smaller gap = greater empowerment).

Data and study sample

The study population was adolescent girls in late adolescence (15–19 years) who (1) were surveyed as part of the most recent DHS VII surveys conducted in Ethiopia, Kenya, Tanzania, and Uganda, (2) were selected for anthropometric and anemia testing, and (3) reported being currently partnered (married) at the time of the survey.

The DHS is a nationally representative cross-sectional survey of women of reproductive age (15–49 years) and men aged 15–49 years, 15–54 years, or 15–59 years. The survey sample is based on a stratified two-stage cluster design that is typically representative at the national level, at the residence level (urban/rural), and the regional level (e.g., states). The DHS uses standardized questionnaires and has large sample sizes (usually between 5,000 and 30,000 households). The surveys are conducted in low- and middle-income countries with support from the U.S. government approximately every five years to allow for comparisons across countries and time.

The DHS is one of the only data sources with cross-country comparable quantitative data on older adolescent girls' (15–19 years) nutrition and empowerment. While the module is not specifically designed for adolescent girls, it can still provide insights into their empowerment and nutrition. The DHS women's status module assesses female respondents' ability to participate in household decision-making (collected for married respondents only), their attitudes toward gender roles, their employment, and their ownership of a house or land.

Outcome measures

We assessed the direct association of dimensions of empowerment on adolescent girls' BMI-for-age (z-score) and haemoglobin levels (Hb) (g/dl). A separate model was tested for each nutrition outcome. Z-scores were calculated using the 2007 WHO growth standards for age and sex [37]. Haemoglobin values were adjusted for altitude and smoking status [38]. Furthermore, we dichotomized respondents' BMI-for-age and haemoglobin outcomes to construct and test models for the following: (1) thinness (ZBFA < -2 SD), (2) anemia (Hb < 12.0 g/dl for non-pregnant respondents and Hb < 11.0 g/dl for pregnant respondents), (3) moderate to severe anemia (Hb < 11.0 g/dl for non-pregnant respondents and Hb < 10.0 g/dl for pregnant respondents), and (4) overweight/obesity (ZBFA > 1 SD).

Covariates

Independent variables for adolescent girls' country of residence, household wealth, breastfeeding status and pregnancy status were included in the model to control for their effects on nutritional status [39–42]. We selected covariates based on a review of similar studies, the content and methodological expertise of the author team, and variable availability in the DHS. The BMI-for-age model controlled for the current breastfeeding status of respondents (yes, no), household wealth (measured as a continuous composite measure of a household's cumulative wealth as part of the DHS), and country of residence. Pregnant respondents were omitted from the BMI-for-age model. We included country of residence as a proxy measure of engrained rules, norms, and practices that shape choice for adolescent girls [23]. Effect coding was used to create dummy variables for country of residence whereby ones, zeros, and negative ones were used to assign group (country) membership [43]. Indicator values represented the deviation of the country value from the unweighted grand mean (UGM) of the outcome variable. The Hb model included the same covariates and controlled for current pregnancy status (yes, no).

Model development and testing

We employed exploratory structural equation modelling (ESEM) with covariates to construct and test our model. Structural equation modelling (SEM) is a group of statistical procedures used for causal inference that tests hypotheses regarding the linear relations among observed variables and latent constructs (or factors) [27]. SEM uses a combination of factor analysis and multiple regression analysis and is appropriate for research questions that involve complex, multifaceted constructs measured with error, and to specify systems of relationships with direct and indirect effects [44]. Because empowerment is multidimensional and cannot be directly measured, SEM offers a viable alternative to multiple regression because it can appropriately accommodate multiple indicators

measuring a latent construct with measurement error. The basic datum analysed in SEM is covariance, which represents the strength of the linear association between two variables. The observed variables can be continuous, censored, binary, ordered categorical (ordinal), and combinations thereof [45]. The goals of SEM are to understand the patterns of covariance among a set of observed variables and to explain as much of their variance as possible with the model. Exploratory structural equation modelling (ESEM) is a less restrictive SEM approach that allows observed variables to (minimally) cross-load onto more than one factor instead of restricting factor loadings to zero on all other factors it is not designed to measure. Such a restriction has been shown to be unrealistic in real world settings and contribute to the inflation of factor correlations and biased estimates [46].

We built the model in a stepwise manner, beginning with an exploratory factor analysis (EFA) of the 24 empowerment indicators (see left-hand side of Fig. 1) using Mplus Version 8 [45]. The Mean- and Variance-Adjusted Weighted Least Squares (WLSMV) estimator was used, and an oblique (geomin) rotation was applied. A series of 1 to 10 factor models were run. Complex survey design was incorporated using TYPE = COMPLEX in the Analysis command along with variables for stratification, weighting, and clustering, as per the DHS survey design for each country. Empowerment indicators were retained if their primary factor loading was above 0.40, below 0.30 for alternative factors, and theoretically justified [47]. Model fit was assessed using recommended model fit indices and corresponding cut-offs [44]. The number of extracted factors was determined by model fit values, scree plot inspection and Eigenvalue > 1, factor interpretability, and parsimony. Factor quality was assessed by examining the number of indicators that loaded on each factor and the correlation between the estimated factor score and the factor [44].

Once a stable EFA structure with good fit was obtained, a nutrition outcome was added to the model to assess the direct effect of each factor (empowerment dimension) on the outcome of interest using regression analysis (right-hand side of Fig. 1). Covariates were added in the following step and model stability and fit were re-assessed. As a final step, modification indices were checked to identify missing paths that were theoretically justified, and improved model fit [44]. Indicators that contributed to a not positive definite residual covariance matrix were investigated and, where appropriate, removed from the model. The model was then re-run. Separate models were run for BMI-for-age, Hb, thinness (ZBFA < -2 SD), overweight and obesity (ZBFA > 1 SD), anemia (Hb < 12.0 g/dl for non-pregnant respondents and Hb < 11.0 g/dl for pregnant respondents), and moderate to severe anemia (Hb < 11.0 g/dl for non-pregnant respondents and Hb < 10.0 g/dl for pregnant respondents). Statistical significance was determined at the $\alpha < 0.05$ level. The unit of analysis was the individual respondent.

Results

Study population characteristics

The total sample size was 1,927 married adolescent girls (Table 1). The mean age of respondents was 17.9 years (SD = 1.1). Most respondents were from the two poorest socio-economic quintiles (57.6%) and lived in rural settings (80.2%). Education levels varied by country, with Ethiopia having the lowest mean level of completed

Table 1 Demographic characteristics and nutritional status of married adolescent girls (15–19 years) from Demographic and Health Surveys conducted in Ethiopia (2016), Kenya (2014), Tanzania (2015–16), and Uganda (2016)

Variable	Regional (*n* = 1,927)	Ethiopia (*n* = 664)	Kenya (*n* = 352)	Tanzania (*n* = 619)	Uganda (*n* = 292)
Mean age (SD)	17.9 (1.1)	17.7 (1.1)	18.0 (1.1)	17.9 (1.2)	18.1 (1.0)
Mean level of completed education (SD)	5.1 (3.4)	3.8 (3.5)	6.5 (3.6)	5.4 (3.0)	5.9 (2.5)
Living in an urban setting, % (n)	19.8 (381)	16.7 (111)	33.8 (119)	17.6 (109)	14.4 (42)
Household wealth below the middle quintile, % (n)	57.6 (1,109)	56.3 (374)	60.8 (214)	55.7 (345)	60.3 (176)
Currently pregnant, % (n)	21.6 (416)	16.1 (107)	22.7 (80)	25.5 (158)	24.3 (71)
Currently breastfeeding, % (n)	41.7 (804)	33.1 (220)	50.3 (175)	43.6 (270)	47.6 (139)
Anemic (Hb < 12.0 g/dl, < 11.0 g/dl (preg)), % (n) [a]	43.8 (664)	32.3 (198)	NA	57.1 (350)	40.1 (116)
Mean BMI (SD) [b]	20.8 (3.1)	19.7 (3.0)	21.0 (3.1)	21.6 (3.3)	21.4 (2.4)
Thin (ZBFA < -2SD), % (n)	3.5 (52)	7.8 (41)	2.6 (7)	0.9 (4)	0.0 (0)
Overweight or obese (ZBFA > 1SD), % (n)	7.0 (103)	3.0 (16)	9.9 (27)	9.0 (41)	8.7 (19)

BMI Body Mass Index, *NA* Not Available. Kenya DHS (2014) did not conduct anemia testing, *SD* Standard Deviation, *ZBFA* BMI-for-age z-score

[a] Total sample size for anemia testing = 1,515

[b] Total sample size for anthropometric measures = 1,476

education (3.8 years, SD = 3.5), and Kenya the highest (6.5 years, SD = 3.6). Almost 22% of respondents were pregnant and 41.2% were breastfeeding at the time of the surveys. The mean BMI of non-pregnant respondents was 20.8 kg/m^2. The prevalence of thinness and overweight (including obesity) among non-pregnant respondents was 3.5 and 7.0%, respectively. Almost 44% of respondents with available data were anemic.

Fifty-five percent of respondents reported listening to the radio while only 28.5% watched TV and 18.9% read the newspaper (Table 2). The highest reported barriers to healthcare were money (41.6%) and distance (44.4%). Respondent's average age at first cohabitation and first sex were 16.1 years and 15.5 years, respectively. Just over 28% earned some cash income. Over 39% owned a house and 32.9% owned land, either alone or jointly. Respondents had the greatest role in household decision-making regarding their own healthcare (67.6%) and the lowest influence on decisions regarding large household purchases (52.3%). Most respondents rejected the view that husbands were justified in beating their wives if they burn food (72.9%), but a majority (51.6%) agreed that violence is justified if a wife neglects the children.

Table 2 Empowerment indicator means, proportions, and factor loadings[a]

Indicator name	Mean value or proportion 'empowered' $n = 1{,}927$	F1	F2	F3	F4	F5	F6
Dimension 1: Access to information							
Completed level of education, mean (SD)	5.1 (3.4)	**0.570**	0.050	0.032	0.084	-0.072	0.150
Watches TV, % (n)	28.5 (549)	**0.635**	0.117	0.039	0.004	-0.091	-0.013
Reads newspaper or magazine, % (n)	18.9 (364)	**0.763**	-0.181	0.016	-0.011	0.003	0.048
Listens to the radio, % (n)	55.0 (1060)	**0.771**	0.025	-0.155	0.004	0.060	-0.035
Dimension 2: Barriers to healthcare							
Getting permission, % (n)	81.4 (1569)	0.002	**0.876**	-0.070	0.017	0.040	0.014
Money, % (n)	54.8 (1056)	0.074	**0.737**	0.021	-0.016	-0.010	-0.024
Distance, % (n)	55.6 (1072)	0.020	**0.878**	0.046	-0.042	-0.037	-0.016
Going alone, % (n)	69.4 (1337)	-0.027	**0.840**	-0.007	0.046	0.024	0.035
Dimension 3: Social independence							
Age at 1st marriage, mean (SD)	16.0 (1.6)	0.053	0.004	-0.038	0.008	0.011	**0.895**
Age at 1st sex, mean (SD)	15.5 (1.7)	0.051	-0.012	0.057	-0.023	0.001	**0.693**
Partner age difference, mean (SD)	-7.4 (4.6)	E	E	E	E	E	E
Partner education difference, mean (SD)	-1.1 (3.7)	E	E	E	E	E	E
Dimension 4: Asset ownership		E	E	E	E	E	E
Earns a cash income, % (n)[b]	28.1 (541)	E	E	E	E	E	E
Owns house alone or jointly, % (n)	39.5 (761)	-0.091	-0.015	0.022	-0.003	**0.827**	0.013
Owns land alone or jointly, % (n)	32.9 (633)	0.033	0.030	0.000	0.006	**0.998**	-0.004
Dimension 5: Role in HH decision-making							
Own healthcare, % (n)	67.6 (1301)	0.099	-0.031	**0.831**	-0.022	0.004	0.008
HH purchases, % (n)	52.3 (1007)	-0.034	0.007	**0.929**	0.013	0.043	-0.024
Visits to family and friends, % (n)	62.1 (1195)	-0.166	0.075	**0.795**	0.060	-0.086	0.042
Use of husband income, % (n)	57.45 (1103)	0.097	-0.046	**0.742**	-0.039	0.081	-0.034
Dimension 6: Rejects IPV							
Goes out without permission, % (n)	55.0 (1059)	-0.035	0.051	0.043	**0.881**	-0.009	-0.029
Burns food, % (n)	72.9 (1404)	0.233	0.030	-0.037	**0.743**	-0.026	0.027
Neglects child, % (n)	48.4 (933)	-0.031	-0.066	-0.006	**0.938**	0.045	-0.046
Refuses sex, % (n)	64.5 (1243)	0.141	-0.016	-0.005	**0.820**	0.010	0.030
Argues with husband, % (n)	53.2 (1025)	-0.001	0.004	0.026	**0.885**	-0.022	0.020

E Eliminated. Indicator was eliminated from the final model because its did not meet the pre-established cut-off, *HH* Household, *IPV* Intimate Partner Violence, *SD* Standard Deviation

[a] A factor loading is the percentage of an indicator's variability explained by a given factor (empowerment dimension)

[b] Proportion of respondents who earned any cash income

Model results

The final model included six empowerment dimensions measured by 21 observed indicators (Table 2) with good model fit (RMSEA = 0.023, CFI = 0.987, TLI = 0.972, SRMR = 0.024). The original six dimensions were retained in the final model; however, three indicators were eliminated because they did not significantly contribute to any dimension: Earns a Cash Income, Age Difference with Partner, Education Difference with Partner.

The final ESEM models for BMI-for-age and haemoglobin are presented in Figs. 2 and 3. The final models included the addition of paths representing the direct influence of household wealth and country of residence on each empowerment dimension based on a review of modification indices and a consideration of their theoretical justification. Model fit results are presented in Additional File 1. Standardized path coefficients for continuous outcomes and adjusted odds ratios (aOR) for binary outcomes with 95% confidence intervals are reported in this section. Unstandardized results are reported in Additional File 1.

Haemoglobin

After controlling for household wealth, country of residence, pregnancy, and breastfeeding, one empowerment dimension, asset ownership, had a direct positive association with haemoglobin levels among respondents (0.148, (0.061, 0.235)) (Table 3 and Fig. 2). Expressed in original units, each one unit increase in asset ownership was associated with a 0.262 (0.108, 0.415) increase in haemoglobin (Additional File 1). No other empowerment dimensions were significantly associated with haemoglobin.

Anemia

Asset ownership was significantly associated with reduced odds of being moderately to severely anemic (aOR = 0.817 (0.716, 0.933)) but the relationship was non-significant ($p > 0.05$) between all empowerment dimensions and anemia when mild cases were included in the model. No other empowerment dimensions were significantly associated with anemia.

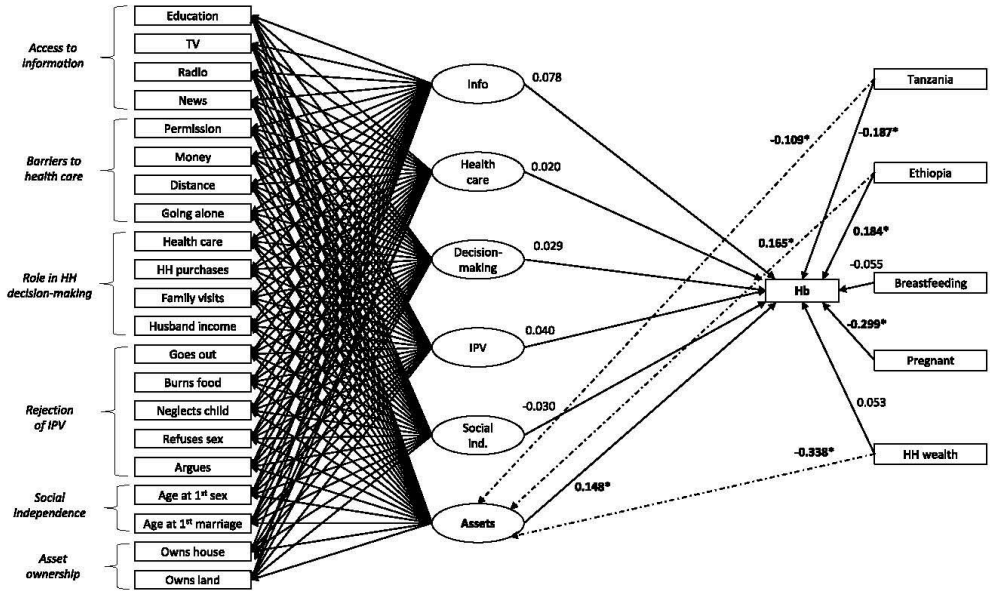


Fig. 2 Final exploratory structural equation model of the relationship between married adolescent girls' haemoglobin levels and empowerment dimensions. Notes: Rectangles indicate observed (directly measured) variables. Ovals represent latent constructs or factors (empowerment dimensions). Unidirectional arrows represent direct effect of exposure on outcome. Values are standardized beta coefficients for respective paths. Bolded values are significant at the 0.05 level. Only statistically significant paths and values are presented. Paths indicated by a dotted line were added to the model following a review of modification indices. Similar paths from household wealth and countries of residence to the remaining empowerment dimensions were statistically significant but are not shown to simplify figure interpretation. Not shown: Error terms for estimated variables, covariance of factors

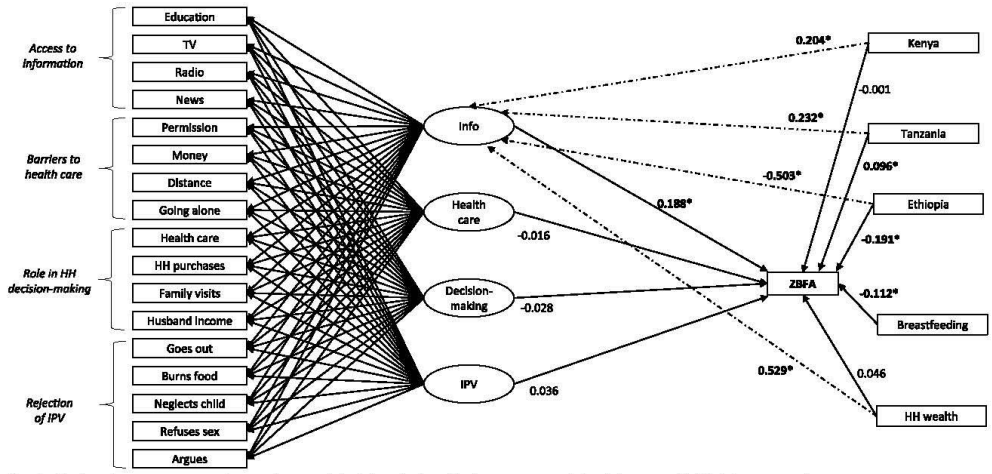


Fig. 3 Final exploratory structural equation model of the relationship between married adolescent girls' BMI-for-age and empowerment dimensions

Table 3 Standardized path coefficients and adjusted odds ratios with 95% confidence intervals for nutrition outcomes by empowerment dimension

Outcome	Access to info	Access to HC	HH decision-making	Rejection of IPV	Social independence	Asset ownership
Hb	0.078 (-0.031, 0.187)	0.020 (-0.060, 0.101)	0.029 (-0.053, 0.110)	0.040 (-0.041, 0.120)	-0.030 (-0.098, 0.037)	**0.148 (0.061, 0.235)**
Anemia[a]	1.005 (0.866, 1.168)	1.015 (0.918, 1.123)	0.966 (0.862, 1.083)	0.989 (0.888, 1.101)	1.046 (0.958, 1.143)	0.928 (0.816, 1.053)
Mod.-sev. anemia[a]	0.872 (0.730, 1.042)	0.974 (0.863, 1.100)	0.954 (0.843, 1.081)	0.905 (0.796, 1.028)	1.046 (0.951, 1.150)	**0.817 (0.716, 0.933)**
ZBFA	**0.188 (0.075, 0.301)**	-0.016 (-0.104, 0.072)	-0.028 (-0.112, 0.055)	0.036 (-0.044, 0.116)	NA	NA
Overweight or obese[a]	1.203 (0.976, 1.481)	0.989 (0.837, 1.169)	0.913 (0.775, 1.076)	**1.168 (1.026, 1.330)**	NA	NA
Thinness[a]	**0.**558[b]	1.088[b]	1.079[b]	1.184[b]		

95%CI 95% confidence interval, *Hb* Haemoglobin (g/dL), *HC* Healthcare, *HH* Household, *IPV* Intimate Partner Violence *NA* Not Applicable, *ZBFA* BMI-for-age z-score
Bolded = $p < 0.05$
[a] Adjusted odds ratio
[b] Confidence intervals too wide to report here

BMI-for-age

The final BMI-for-age model included only four empowerment dimensions: access to information, access to healthcare, role in household decision-making, and rejection of IPV. The remaining empowerment domains – social independence and asset ownership – were removed from the model because they produced negative residual variances. Consequently, access to information was the only empowerment domain directly and positively associated with BMI-for-age (0.188, 95% CI = 0.075, 0.301)) among non-pregnant respondents after controlling for household wealth, breastfeeding status, and country of residence (Table 3 and Fig. 3). Expressed in original units, a one unit increase in access to information was associated with a 0.113 increase in respondents' BMI-for-age z-score. The remaining empowerment domains were non-significant.

Overweight and obesity

Rejecting justifications for IPV was directly and positive associated with the odds of being overweight or obese (aOR = 1.168, (1.026, 1.330)) among non-pregnant respondents, but the sample size was small (only 103

respondents (7%) were overweight or obese). No other empowerment dimensions were significantly associated with being overweight or obese.

Thinness

The relationships between thinness and all empowerment dimensions were non-significant after controlling for country of residence, household wealth, and breastfeeding status in non-pregnant respondents. These results should be interpreted with caution due to the small number of respondents who were thin ($n = 52$ (3.5%)).

Discussion

The relationship between adolescent girls' empowerment and their nutritional status is understudied. This study found a statistically significant association between specific dimensions of married adolescent girls' empowerment and their nutritional status in East Africa using a theoretically informed model of the empowerment-nutrition relationship. Owning assets (a house or land) either alone or jointly was significantly and positively associated with haemoglobin and lower odds of being moderately to severely anemic. Access to information (measured by girls' level of completed education and their mass media use) was significantly and positively associated with BMI-for-age. Rejection of justifications for IPV was associated with the odds of being overweight or obese. No empowerment dimensions were significantly associated with being thin, however the sample size was small. The empowerment dimensions of access to healthcare, role in household decision-making, and social independence were not significantly associated with any assessed nutrition outcomes.

The positive relationships between asset ownership and access to information with haemoglobin and BMI-for-age, respectively, suggest that access to economic and educational resources play an important role in the empowerment-nutrition relationship. In settings where female empowerment is far from complete, such as East Africa, measures of resource access and control may be just as informative as direct measures of agency and may be critical to understanding the process of empowerment [23, 48]. Married adolescent girls who (co-)own a house or land, particularly in places where agriculture is the main source of economy for women, may have greater access to resources in general that can translate into access to a good diet and healthcare. Higher education and mass media use may increase adolescent girls' exposure to nutrition- and diet-related information and indirectly affect their nutritional status by reducing adolescent fertility and delaying marriage and childbearing. On the other hand, peer influence, the changing food environment, and mass/social media can promote unhealthy nutrition-related behaviours, such as increased consumption of ultra-processed foods, as well as unhealthy conceptualizations of body image [13, 49]. Rejection of justifications of IPV, a measure of girls' intrinsic agency, was associated with increased odds of being overweight or obese in our study population. A possible explanation is that girls with higher levels of intrinsic agency have greater freedom to exercise choice in their diet and may therefore choose to eat foods that are popular or convenient but may be lacking in nutritional value.

We did not find any significant associations between nutrition outcomes and adolescent girls' social independence. Age at first marriage and first sex (the indicators used to measure social independence) have been previously shown to be associated with nutrition; women who delay marriage and childbearing generally have better maternal and child health and nutrition outcomes. It may be that the absence of important mediating variables along the causal chain from social independence to nutritional status, such as level of education, are needed to help explain the relationship.

Girls' ability to overcome barriers to healthcare access was not significantly associated with their BMI-for-age or haemoglobin. We hypothesized that given our study population was generally healthy (mean Hb = 12.0 g/dL, mean BMI = 20.8 kg/m^2), they may not regularly seek healthcare, making it difficult to detecting a statistical relationship with nutritional status.

Recent studies have identified three- and four-factor models for women's empowerment in sub-Saharan Africa that resemble our dimensions for social independence, role in household decision-making, and rejection of IPV [32, 50–52]. Jones and colleagues used structural equation modelling to assess the relationship between married women's (15–49) empowerment and nutritional status in five East African countries [21]. Their model included the three domains listed above and found significant positive associations between all three domains and women's BMI, and between role in household decision-making and haemoglobin. We were unable to identify a statistically significant association between household decision-making and adolescent girls' nutrition, but this measure may be less meaningful for married adolescent girls as they are less likely to hold sway in the household compared to adult women, their husbands, and in-laws.

There is limited understanding of how variations in age and context affect girls' empowerment [12]. While our data included older adolescents only, we were able to explore the influence of selected contextual factors on empowerment and nutrition. Our initial model did not include pathways from covariates representing

household wealth and country of residence to empowerment dimensions, but the models' modifications indices recommended the addition of these paths to reflect the significant relationship between these contextual measures and empowerment. Context-specific structural characteristics, such as socio-economic status and gendered norms, beliefs, and practices, can constrain girls' choices and influence their behaviour, values, and preferences. Geographic measures, such as country of residence, can act as proxy indicators for engrained rules, norms, and practices that shape girls' agency [23]. Others have similarly found that levels of empowerment vary by country and household wealth [21, 50, 53]. Existing models of adolescent empowerment recognize that supportive laws, policies, structures, and adults/decision-makers are a crucial influence on pathways from adolescent empowerment to improved health and well-being [11, 12, 54]. These relationships undoubtedly vary by household, community, region, and state, and must be examined when seeking to design and measure meaningful empowerment-related change. In East Africa, continued high rates of HIV infection among adolescents, especially girls, is an important contextual factor given the intersection of the HIV/AIDS epidemic and adolescent health seeking behaviour in this region [55].

Our greatest limitation was data availability. There are few choices for researchers seeking datasets that include both gender-related and health-related data. The DHS is one of the few options available, but it is not designed for analyses of adolescent populations and does not collect data for younger adolescents (aged 10–14 years), nor does it collect the women's status module for unmarried women and adolescents. We were unable to test single country models because of small country sample sizes for our target population, and our results suggest that this would be meaningful given country of residence is directly related to empowerment. The DHS also lacks measures for other potentially important empowerment dimensions and confounders of the nutrition-empowerment relationship. We included as many relevant and available empowerment indicators and covariates as possible and maximized our sample by pooling country datasets to form a regional sample to overcome these limitations. However, we still had two dimensions measured by only two indicators, which led to the elimination of both dimensions in the BMI-for-age model because of model instability. One benefit of using DHS data is that this model can be used to test the association of dimensions of empowerment with other health outcomes and across contexts due to its standardized format that allows cross-country and -time comparisons.

Our findings suggest that investment in girls' access to information through education and mass/social media remains an important strategy for their empowerment and nutrition. Others have similarly argued that investing in secondary education, particularly for girls, provides extensive opportunities for health and well-being. [56] This will require investments in interventions that address some of the greatest gender-related barriers to girls' education, including restrictive gender norms that devalue girls' education, cultural practices of child/early/forced marriage and early pregnancy, and inadequate water and sanitation facilities in schools. Schools can also serve as important platforms for health promotion and services, such as nutrition education and iron and folic acid supplementation [11].

Recent evidence points to the value of social media for addressing overnutrition. Increasing rates of overweight and obesity in the region signal the need to invest in these areas as well. However, low access to digital technology in the region could be an impediment [57]. Caution should also be exercised given the potentially negative influence of social media on body image and the ability of industry to directly market unhealthy food and beverage choices to adolescents through various media platforms [7, 49].

The economic empowerment of adolescent girls is receiving increasing attention, whether it is through examining gender disparities in economic opportunities between adolescent boys and girls [58], or the incorporation of economic empowerment strategies in adolescent nutrition interventions, such as income generating activities, savings and loan program, and life skills training [59, 60]. Our findings suggest that adolescent girls' economic empowerment may influence their haemoglobin levels, but we could not test this relationship for BMI-for-age due to modelling limitations. Others have found equivocal results on the economic empowerment and nutrition link for adolescent girls as well [59]. More investigation is warranted.

There is an urgent need for better data on adolescent empowerment and health to facilitate research on the gendered pathways to better health for adolescents. This includes the need for datasets to be sufficiently powered to analyse other socially stratifying factors such as ethnicity and disability, and more balanced data that captures gender-related measures for boys and girls [58, 59, 61, 62]. Much work remains to further our understanding of the mechanisms of action that link adolescent girls' empowerment and nutrition. Studies that assess causality and further our options for validated measures across contexts are needed. This latter point cannot replace the importance of understanding the role of context in the empowerment process, such as the reasons behind varying levels of empowerment by country. The use of statistical models should be complemented by robust qualitative research to further results interpretation.

Abbreviations

BMI	Body mass index
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
DHS	Demographic and Health Survey
EFA	Exploratory factor analysis
ESEM	Exploratory structural equation model
Hb	Haemoglobin
HIV	Human immunodeficiency virus
IPV	Intimate partner violence
IRB	Institutional Review Board
RMSEA	Root mean square error of approximation
SD	Standard deviation
SEM	Structural equation model
SRMR	Standardized root mean square residual
TLI	Tucker-Lewis index
UGM	Unweighted grand mean
WHO	World Health Organization
WLSMV	Variance-adjusted weighted least squares
ZBFA	BMI-for-age z-score

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-022-14949-1.

Additional file 1: Table A1. Model indicator descriptions and coding. **Table A2.** Unstandardized path coefficients with 95% confidence intervals for nutrition outcomes by empowerment dimension. **Table A3.** Standardized path coefficients with 95% confidence intervals for nutrition outcomes by empowerment dimension. **Table A4.** Model fit results. **Table A5.** Standardized path coefficients and 95% confidence intervals for nutrition outcomes by empowerment domain for models including additional covariates. **Table A6.** Model fit results for models with additional covariates. **Table A7.** Standardized path coefficients and 95% confidence intervals for the direct association of model covariates and empowerment dimensions.

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Not applicable.

Additional materials
Additional materials related to this study's methods and results, such as unstandardized path coefficients, that are referenced in this manuscript can be found in Additional File 1 (docx file).

Authors' contributions
AYR conceived the study and wrote the original draft. AYR, WL, GAW, and VW verified the underlying data. AYR, WL, ZAB, MT, CV, EK, GAW, VW contributed to the study methodology. AYR with support from WL conducted the investigation and formal analyses with supervision from GAW and VW. All authors contributed to the review and editing of the article. AYR, GAW, and VW secured funding for the study. All authors had final responsibility for the decision to submit for publication. The author(s) read and approved the final manuscript.

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Availability of data and materials
The datasets analysed during the current study are available from the Demographic and Health Survey Program, https://dhsprogram.com/Data/.

Declarations

Ethics approval and consent to participate
The DHS Program maintains strict standards for protecting the privacy of respondents and household members in all DHS surveys. All data are anonymized before use. Procedures and questionnaires for standard DHS surveys have been reviewed and approved by ICF Institutional Review Board (IRB). Country-specific DHS survey protocols are reviewed by the ICF IRB and typically by an IRB in the host country. Permission to access the raw data was provided by the DHS Program. Informed consent was obtained from all respondents in the survey before asking questions, and separately before obtaining biomarker and anthropometric measurements. Respondents who did not provide consent were excluded from the analysis for the current study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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APPENDIX A3: Mplus code

Example 1.

This is the Mplus code used to model Hb on six empowerment domains for married adolescent girls.

```
C:\Users\Alison Riddle\Dropbox\PhD\ESEM\2. Married ad...\ESEM married HB code 20220410.inp

TITLE: ESEM for married girls ALL - Hb; !CORRECT TITLE AS NEEDED;

DATA: FILE =
"C:\Users\Alison Riddle\Dropbox\PhD\ESEM\2. Married adolescents\Mplus\
EA_married_addcov.csv";

VARIABLE:
NAME =
news tv radio educ permis money distance alone V511
v531r agediff edudiff earning house land health purchase
visit husband out burns neglect refuse argue wealth v404
v213 country v012 v102 v190 v113 v116 v136 v150
v201 v218 wgt hgt hb CBMI ZBFA thin underwgt
anemia sevanemia weight strat cluster overwgt ETH TZA KEN;

SUBPOPULATION = country NE 33; !Exclude Kenya

USEVARIABLE =
Hb
weight strat cluster
educ tv news radio
permis money distance alone
V511 V531r
health purchase visit husband
house land
out burns neglect refuse argue !CHECK ALL VARIABLES ARE PRESENT;
v404 wealth ETH TZA;! v102 v113 v136 v201; !KEN v213

CATEGORICAL =
tv news radio
permis money distance alone
health purchase visit husband
house land
out burns neglect refuse argue; !CHECK ALL VARIABLES ARE PRESENT;

MISSING = .;
WEIGHT = weight;
CLUSTER = cluster;
STRATIFICATION = strat;
ANALYSIS:
TYPE = COMPLEX;

MODEL:
f1-f6 BY educ tv news radio
permis money distance alone
v511 v531r
```

```
health purchase visit husband
house land
out burns neglect refuse argue (*esem); !CHECK ALL VARIABLES ARE PRESENT;

hb ON f1-f6 v404 wealth ETH TZA;! v102 v113 v136 v201; !v213

f1-f6 ON wealth ETH TZA; !CHECK ALL VARIABLES ARE PRESENT;

OUTPUT: STANDARDIZED MODINDICES (ALL) CINTERVAL TECH1 TECH2 TECH3 TECH4;
PLOT: TYPE = PLOT2;
```

Example 2

This is the Mplus code used to model Hb on three empowerment domains for single adolescent girls.

```
C:\Users\Alison Riddle\Dr...\Regional ESEM in CFA framework single girls - Hb 20220526.inp

TITLE: HB ESEM in CFA for single girls Regional; !CORRECT TITLE AS NEEDED;

DATA: FILE =
"C:\Users\Alison Riddle\Dropbox\PhD\ESEM\1. Single adolescents\Mplus\regional_hb.csv";

VARIABLE:
NAME =
V001 V002 V003 V005 V012 V021 V023 v042 V102 V133 V150
V151 V152 V155 v190 V191 V213 V404 V437 V438 v447 v455
V456 V457 V531 V731 V732 school news radio tv permis money
distance alone out neglect argue refuse burns house land earning v511
sex wgt hgt hb wealth weight educ country agemons CBMI ZHFA ZBFA FHFA
FBFA thin underwgt anemia sevanemia overwgt strat cluster ETH TZA KEN
RWA wealth3;

!GROUPING IS country (11=Ethiopia 22=Tanzania 44=Uganda 55=Rwanda);
!GROUPING IS V190 (1=Poorest 2 = Poorer 3=Middle 4=Richer 5=Richest);
!GROUPING IS wealth3 (1 = Poor 2 = Middle 3 = Rich);
!GROUPING IS v102 (1 = Urban 2 = Rural);
!GROUPING IS school (2 = inschool 0 = outschool);

USEVARIABLE =
!outcome variable zbfa thin sevanem hb
hb
!complex survey variables weight strat cluster
weight strat cluster
!covariates
!No KEN for hb and anemia models
ETH TZA RWA wealth
!empowerment variables
!educ tv news radio
!permis money distance alone
!out burns neglect refuse argue;
educ tv news radio
```

```
permis money distance alone
out burns neglect refuse argue;

CATEGORICAL =
!thin overwgt anemia sevanem
tv news radio
permis money distance alone
out burns neglect refuse argue;

MISSING = .;
WEIGHT = weight;
CLUSTER = cluster;
STRATIFICATION = strat;

ANALYSIS:
TYPE = COMPLEX;
STARTS = 20;
!ROTATION = target; ! No rotation needed for CFA

MODEL:
Info BY educ@1.602 tv*0.664 news*0.783 radio*0.657
permis@-0.002 money*0.054 distance*0.008 alone*-0.037
out@-0.051 burns*0.166 neglect*-0.135 refuse*0.073 argue*-0.015;

Health BY permis@0.816 money*0.734 distance*0.831 alone*0.798
educ@0.052 tv*0.078 news*-0.112 radio*0.082
out@0.032 burns*0.017 neglect*-0.002 refuse*-0.053 argue*0.007;

IPV BY out@0.881 burns*0.777 neglect*0.917 refuse*0.822 argue*0.905
educ@0.329 tv*-0.013 news*-0.026 radio*-0.017
permis@0.038 money*-0.029 distance*0.012 alone*-0.016;

Info*; Health*; IPV*;!free factor estimates;

hb ON info health IPV ETH TZA RWA wealth;

info ON ETH TZA RWA wealth;

health ON ETH TZA RWA wealth;

IPV ON ETH TZA RWA wealth;

OUTPUT: STANDARDIZED MODINDICES CINTERVAL;
PLOT: TYPE = PLOT2;
```

APPENDIX A4: Mplus output

```
Mplus VERSION 8.7
MUTHEN & MUTHEN
04/10/2022   3:54 PM

INPUT INSTRUCTIONS

  TITLE: ESEM for married girls ALL - Hb; !CORRECT TITLE AS NEEDED;


  DATA: FILE =
  "C:\Users\Alison Riddle\Dropbox\PhD\ESEM\2. Married adolescents\Mplus\EA_married_all.csv
";

  VARIABLE:

  NAME =
  news  tv  radio   educ    permis  money   distance    alone
  V511  v531r   agediff edudiff earning house   land
  health    purchase    visit   husband out burns   neglect refuse  argue
  wealth    v404    v213    country v012    v102    v190
  wgt   hgt hb  CBMI    ZBFA    thin    underwgt    anemia  sevanemia
  weight    strat   cluster overwgt overweight  ETH TZA KEN;

  SUBPOPULATION = country NE 33; !Exclude Kenya;

  USEVARIABLE =
  Hb

  weight strat cluster

  educ tv news radio
  permis money distance alone
  V511 V531r
  health purchase visit husband
  house land
  out burns neglect refuse argue !CHECK ALL VARIABLES ARE PRESENT;
  v404 wealth ETH TZA v213; !KEN ;

  CATEGORICAL =
  tv news radio
  permis money distance alone
  health purchase visit husband
  house land
  out burns neglect refuse argue; !CHECK ALL VARIABLES ARE PRESENT;


  MISSING = .;
  WEIGHT = weight;
  CLUSTER = cluster;
  STRATIFICATION = strat;

  ANALYSIS:
  TYPE = COMPLEX;

  MODEL:

  f1-f6 BY educ tv news radio
  permis money distance alone
  v511 v531r
  health purchase visit husband
  house land
  out burns neglect refuse argue (*esem); !CHECK ALL VARIABLES ARE PRESENT;

  hb ON f1-f6 v213 v404 wealth ETH TZA;
```

```
  f1-f6 ON wealth ETH TZA; !CHECK ALL VARIABLES ARE PRESENT;

  OUTPUT: STANDARDIZED MODINDICES (ALL) CINTERVAL;

  PLOT: TYPE = PLOT2;



INPUT READING TERMINATED NORMALLY


ESEM for married girls ALL - Hb;

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                        1575

Number of dependent variables                                   22
Number of independent variables                                  5
Number of continuous latent variables                            6

Observed dependent variables

  Continuous
   HB          EDUC        V511        V531R

  Binary and ordered categorical (ordinal)
   TV          NEWS        RADIO       PERMIS      MONEY       DISTANCE
   ALONE       HEALTH      PURCHASE    VISIT       HUSBAND     HOUSE
   LAND        OUT         BURNS       NEGLECT     REFUSE      ARGUE

Observed independent variables
   V404        WEALTH      ETH         TZA         V213

Continuous latent variables

  EFA factors
  *esem:   F1          F2          F3          F4          F5          F6

Variables with special functions

  Stratification        STRAT
  Cluster variable      CLUSTER
  Weight variable       WEIGHT

Estimator                                                     WLSMV
Rotation                                                      GEOMIN
Row standardization                                       CORRELATION
Type of rotation                                             OBLIQUE
Epsilon value                                                 Varies
Maximum number of iterations                                    1000
Convergence criterion                                     0.500D-04
Maximum number of steepest descent iterations                     20
Maximum number of iterations for H1                             2000
Convergence criterion for H1                              0.100D-03
Optimization Specifications for the Exploratory Factor Analysis
Rotation Algorithm
  Number of random starts                                       30
  Maximum number of iterations                               10000
  Derivative convergence criterion                          0.100D-04
```

Parameterization DELTA
Link PROBIT

Input data file(s)
C:\Users\Alison Riddle\Dropbox\PhD\ESEM\2. Married adolescents\Mplus\EA_marrie

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 6
Number of strata 115
Number of clusters 903

UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

TV		
Category 1	0.729	1148.690
Category 2	0.271	426.310
NEWS		
Category 1	0.790	1243.782
Category 2	0.210	331.218
RADIO		
Category 1	0.452	711.371
Category 2	0.548	863.629
PERMIS		
Category 1	0.247	389.217
Category 2	0.753	1185.783
MONEY		
Category 1	0.479	754.015
Category 2	0.521	820.985
DISTANCE		
Category 1	0.517	814.064
Category 2	0.483	760.936
ALONE		
Category 1	0.399	627.902
Category 2	0.601	947.098
HEALTH		
Category 1	0.318	500.865
Category 2	0.682	1073.127
PURCHASE		
Category 1	0.498	783.613
Category 2	0.502	790.379
VISIT		
Category 1	0.380	598.555
Category 2	0.620	975.437
HUSBAND		
Category 1	0.419	659.335
Category 2	0.581	912.896
HOUSE		
Category 1	0.619	975.690
Category 2	0.381	599.310
LAND		
Category 1	0.663	1043.941
Category 2	0.337	531.059
OUT		
Category 1	0.492	774.140
Category 2	0.508	800.860
BURNS		
Category 1	0.335	526.886
Category 2	0.665	1048.114
NEGLECT		

Category 1	0.564	888.920
Category 2	0.436	686.080
REFUSE		
Category 1	0.375	590.780
Category 2	0.625	984.220
ARGUE		
Category 1	0.509	802.044
Category 2	0.491	772.956

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/ Sample Size	Mean/ Variance	Skewness/ Kurtosis	Minimum/ Maximum	% with Min/Max	20%/60%	Percentiles 40%/80%	Median
HB	12.002	-0.690	1.800	0.07%	10.400	11.600	12.000
1515.000	3.630	1.430	17.800	0.07%	12.500	13.400	
EDUC	4.877	-0.250	0.000	21.78%	0.000	5.000	6.000
1575.000	10.150	-0.896	15.000	0.06%	7.000	7.000	
V511	15.975	-0.565	4.000	0.06%	15.000	16.000	16.000
1575.000	2.605	1.205	19.000	3.37%	16.000	17.000	
V531R	15.520	-0.427	8.000	0.51%	14.000	15.000	16.000
1567.000	2.378	0.647	19.000	1.60%	16.000	17.000	
V404	0.419	0.327	0.000	60.06%	0.000	0.000	0.000
1575.000	0.243	-1.893	1.000	39.94%	0.000	1.000	
WEALTH	-0.371	1.608	-1.714	0.06%	-0.938	-0.706	-0.588
1575.000	0.495	2.402	2.588	0.06%	-0.465	-0.008	
ETH	0.202	-0.326	-1.000	18.54%	0.000	0.000	0.000
1575.000	0.524	-1.051	1.000	42.16%	1.000	1.000	
TZA	0.254	-0.447	-1.000	18.54%	0.000	0.000	0.000
1575.000	0.552	-1.081	1.000	39.30%	0.000	1.000	
V213	0.207	1.445	0.000	78.67%	0.000	0.000	0.000
1575.000	0.164	0.087	1.000	21.33%	0.000	1.000	

WARNING: THE VARIANCE CONTRIBUTION FROM A STRATUM WITH A SINGLE CLUSTER (PSU) IS BASED ON THE DIFFERENCE BETWEEN THE SINGLE CLUSTER VALUE AND THE OVERALL CLUSTER MEAN.

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 166

Chi-Square Test of Model Fit

```
          Value                            437.478*
          Degrees of Freedom                  201
          P-Value                          0.0000

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                          0.027
          90 Percent C.I.                   0.024  0.031
          Probability RMSEA <= .05          1.000

CFI/TLI

          CFI                               0.966
          TLI                               0.942

Chi-Square Test of Model Fit for the Baseline Model

          Value                          7222.768
          Degrees of Freedom                  341
          P-Value                          0.0000

SRMR (Standardized Root Mean Square Residual)

          Value                             0.042

Optimum Function Value for Weighted Least-Squares Estimator

          Value                     0.10650600D+00


MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 F1       BY
    EDUC               1.440      0.103     14.015      0.000
    TV                 0.551      0.047     11.714      0.000
    NEWS               0.665      0.043     15.349      0.000
    RADIO              0.632      0.041     15.279      0.000
    PERMIS             0.014      0.029      0.480      0.631
    MONEY              0.035      0.028      1.227      0.220
    DISTANCE          -0.005      0.023     -0.205      0.838
    ALONE             -0.019      0.027     -0.694      0.488
    V511               0.233      0.060      3.893      0.000
    V531R             -0.042      0.019     -2.231      0.026
    HEALTH             0.108      0.041      2.612      0.009
    PURCHASE          -0.030      0.014     -2.181      0.029
    VISIT             -0.118      0.038     -3.118      0.002
    HUSBAND            0.095      0.031      3.087      0.002
    HOUSE             -0.072      0.034     -2.107      0.035
    LAND               0.041      0.016      2.545      0.011
    OUT               -0.051      0.024     -2.138      0.032
    BURNS              0.204      0.038      5.316      0.000
    NEGLECT           -0.035      0.020     -1.766      0.077
    REFUSE             0.092      0.032      2.857      0.004
    ARGUE             -0.005      0.019     -0.274      0.784
```

F2	BY				
	EDUC	0.031	0.078	0.402	0.687
	TV	0.127	0.059	2.152	0.031
	NEWS	-0.115	0.071	-1.631	0.103
	RADIO	0.053	0.044	1.197	0.231
	PERMIS	0.872	0.027	32.676	0.000
	MONEY	0.753	0.029	25.878	0.000
	DISTANCE	0.879	0.027	33.023	0.000
	ALONE	0.799	0.030	26.220	0.000
	V511	-0.030	0.034	-0.889	0.374
	V531R	0.017	0.021	0.833	0.405
	HEALTH	-0.018	0.028	-0.636	0.525
	PURCHASE	0.004	0.026	0.163	0.871
	VISIT	0.074	0.040	1.850	0.064
	HUSBAND	-0.050	0.056	-0.899	0.368
	HOUSE	-0.028	0.033	-0.843	0.399
	LAND	0.037	0.028	1.316	0.188
	OUT	0.057	0.036	1.599	0.110
	BURNS	0.003	0.040	0.082	0.935
	NEGLECT	-0.034	0.035	-0.971	0.331
	REFUSE	-0.027	0.033	-0.804	0.421
	ARGUE	0.018	0.032	0.554	0.579
F3	BY				
	EDUC	0.335	0.111	3.020	0.003
	TV	0.004	0.037	0.103	0.918
	NEWS	0.023	0.037	0.627	0.531
	RADIO	-0.086	0.052	-1.664	0.096
	PERMIS	-0.056	0.034	-1.637	0.102
	MONEY	-0.010	0.032	-0.325	0.745
	DISTANCE	0.039	0.030	1.299	0.194
	ALONE	0.027	0.033	0.826	0.409
	V511	-0.021	0.031	-0.666	0.506
	V531R	0.006	0.021	0.295	0.768
	HEALTH	0.833	0.025	33.460	0.000
	PURCHASE	0.953	0.022	43.701	0.000
	VISIT	0.795	0.029	27.573	0.000
	HUSBAND	0.726	0.043	16.942	0.000
	HOUSE	0.033	0.033	0.987	0.324
	LAND	-0.007	0.018	-0.376	0.707
	OUT	0.040	0.033	1.241	0.215
	BURNS	-0.013	0.036	-0.353	0.724
	NEGLECT	-0.011	0.030	-0.360	0.719
	REFUSE	-0.008	0.032	-0.251	0.802
	ARGUE	0.007	0.027	0.263	0.792
F4	BY				
	EDUC	0.071	0.080	0.882	0.378
	TV	-0.018	0.046	-0.388	0.698
	NEWS	0.034	0.040	0.844	0.399
	RADIO	-0.022	0.042	-0.519	0.604
	PERMIS	0.012	0.034	0.361	0.718
	MONEY	0.026	0.033	0.777	0.437
	DISTANCE	-0.043	0.033	-1.291	0.197
	ALONE	0.021	0.036	0.586	0.558
	V511	0.044	0.033	1.312	0.190
	V531R	-0.040	0.022	-1.850	0.064
	HEALTH	-0.036	0.037	-0.989	0.322
	PURCHASE	0.003	0.028	0.093	0.926
	VISIT	0.063	0.040	1.601	0.109
	HUSBAND	-0.017	0.034	-0.507	0.612
	HOUSE	-0.003	0.029	-0.107	0.915
	LAND	0.004	0.022	0.197	0.844

OUT	0.884	0.020	43.861	0.000
BURNS	0.781	0.029	27.181	0.000
NEGLECT	0.928	0.016	56.457	0.000
REFUSE	0.843	0.023	36.238	0.000
ARGUE	0.895	0.020	44.182	0.000
F5 BY				
EDUC	0.352	0.096	3.662	0.000
TV	-0.045	0.039	-1.150	0.250
NEWS	0.021	0.033	0.635	0.525
RADIO	-0.014	0.033	-0.422	0.673
PERMIS	0.010	0.030	0.317	0.751
MONEY	-0.014	0.027	-0.525	0.599
DISTANCE	-0.039	0.031	-1.266	0.205
ALONE	0.059	0.036	1.639	0.101
V511	1.000	0.101	9.940	0.000
V531R	1.465	0.144	10.156	0.000
HEALTH	0.005	0.029	0.162	0.871
PURCHASE	-0.008	0.022	-0.377	0.706
VISIT	0.031	0.029	1.067	0.286
HUSBAND	-0.040	0.034	-1.177	0.239
HOUSE	0.017	0.024	0.717	0.473
LAND	-0.003	0.019	-0.167	0.867
OUT	-0.005	0.027	-0.204	0.838
BURNS	0.014	0.034	0.425	0.671
NEGLECT	-0.024	0.028	-0.836	0.403
REFUSE	0.012	0.029	0.425	0.671
ARGUE	0.001	0.025	0.051	0.959
F6 BY				
EDUC	-0.300	0.115	-2.610	0.009
TV	-0.038	0.047	-0.818	0.413
NEWS	0.038	0.045	0.849	0.396
RADIO	0.069	0.050	1.382	0.167
PERMIS	0.032	0.039	0.815	0.415
MONEY	0.044	0.037	1.186	0.236
DISTANCE	-0.046	0.039	-1.181	0.238
ALONE	-0.001	0.030	-0.047	0.963
V511	-0.044	0.036	-1.236	0.217
V531R	0.048	0.024	2.047	0.041
HEALTH	-0.001	0.027	-0.036	0.972
PURCHASE	0.037	0.029	1.271	0.204
VISIT	-0.075	0.042	-1.771	0.077
HUSBAND	0.076	0.051	1.468	0.142
HOUSE	0.796	0.062	12.825	0.000
LAND	0.987	0.071	13.857	0.000
OUT	-0.016	0.029	-0.543	0.587
BURNS	-0.041	0.039	-1.064	0.287
NEGLECT	0.035	0.033	1.046	0.296
REFUSE	0.021	0.033	0.648	0.517
ARGUE	-0.002	0.029	-0.053	0.957
F1 ON				
WEALTH	0.849	0.080	10.556	0.000
ETH	-0.859	0.082	-10.488	0.000
TZA	0.697	0.070	10.013	0.000
F2 ON				
WEALTH	0.448	0.067	6.714	0.000
ETH	-0.354	0.065	-5.411	0.000
TZA	-0.009	0.056	-0.169	0.865
F3 ON				
WEALTH	0.134	0.052	2.554	0.011

ETH	0.562	0.072	7.812	0.000
TZA	-0.356	0.055	-6.412	0.000
F4 ON				
WEALTH	0.200	0.048	4.182	0.000
ETH	-0.137	0.064	-2.127	0.033
TZA	-0.125	0.049	-2.525	0.012
F5 ON				
WEALTH	0.240	0.061	3.961	0.000
ETH	-0.126	0.065	-1.942	0.052
TZA	-0.088	0.049	-1.802	0.071
F6 ON				
WEALTH	-0.517	0.069	-7.516	0.000
ETH	0.246	0.073	3.389	0.001
TZA	-0.157	0.065	-2.410	0.016
HB ON				
F1	0.111	0.078	1.417	0.156
F2	0.036	0.072	0.496	0.620
F3	0.050	0.072	0.694	0.487
F4	0.074	0.077	0.959	0.338
F5	-0.056	0.064	-0.881	0.378
F6	0.262	0.078	3.348	0.001
HB ON				
V213	-1.405	0.158	-8.912	0.000
V404	-0.213	0.140	-1.524	0.128
WEALTH	0.145	0.112	1.285	0.199
ETH	0.485	0.118	4.107	0.000
TZA	-0.480	0.108	-4.457	0.000
F2 WITH				
F1	0.110	0.053	2.086	0.037
F3 WITH				
F1	0.056	0.049	1.124	0.261
F2	0.061	0.062	0.989	0.323
F4 WITH				
F1	0.107	0.044	2.451	0.014
F2	0.136	0.050	2.722	0.006
F3	0.162	0.049	3.323	0.001
F5 WITH				
F1	0.148	0.046	3.217	0.001
F2	-0.028	0.044	-0.631	0.528
F3	0.083	0.040	2.042	0.041
F4	0.115	0.043	2.677	0.007
F6 WITH				
F1	0.043	0.061	0.695	0.487
F2	0.007	0.060	0.121	0.904
F3	0.084	0.049	1.701	0.089
F4	-0.101	0.050	-2.021	0.043
F5	-0.016	0.047	-0.347	0.728
Intercepts				
HB	12.467	0.107	117.050	0.000
EDUC	5.744	0.164	34.952	0.000
V511	16.479	0.090	184.033	0.000
V531R	15.899	0.086	183.863	0.000

Thresholds				
TV$1	0.385	0.087	4.419	0.000
NEWS$1	0.764	0.082	9.270	0.000
RADIO$1	-0.372	0.087	-4.277	0.000
PERMIS$1	-0.913	0.092	-9.952	0.000
MONEY$1	-0.283	0.072	-3.920	0.000
DISTANCE$1	-0.247	0.073	-3.398	0.001
ALONE$1	-0.403	0.072	-5.641	0.000
HEALTH$1	-0.487	0.079	-6.157	0.000
PURCHASE$1	-0.085	0.079	-1.082	0.279
VISIT$1	-0.395	0.074	-5.318	0.000
HUSBAND$1	-0.179	0.070	-2.550	0.011
HOUSE$1	0.590	0.078	7.534	0.000
LAND$1	0.709	0.080	8.870	0.000
OUT$1	-0.069	0.076	-0.906	0.365
BURNS$1	-0.682	0.081	-8.468	0.000
NEGLECT$1	0.149	0.079	1.891	0.059
REFUSE$1	-0.501	0.077	-6.497	0.000
ARGUE$1	-0.012	0.078	-0.154	0.878
Residual Variances				
HB	2.999	0.125	23.922	0.000
EDUC	5.094	0.365	13.973	0.000
V511	1.173	0.186	6.291	0.000
V531R	0.144	0.395	0.364	0.716
F1	1.000	0.000	999.000	999.000
F2	1.000	0.000	999.000	999.000
F3	1.000	0.000	999.000	999.000
F4	1.000	0.000	999.000	999.000
F5	1.000	0.000	999.000	999.000
F6	1.000	0.000	999.000	999.000

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.314E-04
(ratio of smallest to largest eigenvalue)

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
EDUC	0.623	0.031	20.096	0.000
TV	0.651	0.048	13.625	0.000
NEWS	0.785	0.039	20.157	0.000
RADIO	0.736	0.040	18.320	0.000
PERMIS	0.018	0.037	0.481	0.630
MONEY	0.044	0.036	1.232	0.218
DISTANCE	-0.006	0.029	-0.205	0.838
ALONE	-0.024	0.034	-0.693	0.488
V511	0.200	0.050	4.036	0.000
V531R	-0.037	0.017	-2.184	0.029
HEALTH	0.138	0.053	2.600	0.009
PURCHASE	-0.037	0.017	-2.131	0.033
VISIT	-0.148	0.046	-3.187	0.001
HUSBAND	0.123	0.040	3.051	0.002
HOUSE	-0.090	0.043	-2.117	0.034
LAND	0.052	0.020	2.552	0.011

OUT	-0.068	0.032	-2.135	0.033
BURNS	0.261	0.049	5.368	0.000
NEGLECT	-0.046	0.026	-1.769	0.077
REFUSE	0.121	0.042	2.869	0.004
ARGUE	-0.007	0.024	-0.274	0.784
F2 BY				
EDUC	0.011	0.027	0.403	0.687
TV	0.120	0.056	2.149	0.032
NEWS	-0.109	0.069	-1.595	0.111
RADIO	0.050	0.042	1.192	0.233
PERMIS	0.884	0.026	34.341	0.000
MONEY	0.775	0.030	25.923	0.000
DISTANCE	0.896	0.026	34.758	0.000
ALONE	0.821	0.030	27.469	0.000
V511	-0.021	0.023	-0.891	0.373
V531R	0.012	0.015	0.834	0.404
HEALTH	-0.018	0.029	-0.636	0.525
PURCHASE	0.004	0.026	0.163	0.871
VISIT	0.074	0.040	1.853	0.064
HUSBAND	-0.052	0.058	-0.902	0.367
HOUSE	-0.028	0.033	-0.845	0.398
LAND	0.037	0.028	1.318	0.187
OUT	0.060	0.038	1.607	0.108
BURNS	0.003	0.041	0.082	0.935
NEGLECT	-0.036	0.037	-0.969	0.333
REFUSE	-0.028	0.035	-0.804	0.422
ARGUE	0.019	0.034	0.554	0.579
F3 BY				
EDUC	0.118	0.039	3.042	0.002
TV	0.004	0.036	0.103	0.918
NEWS	0.022	0.036	0.624	0.533
RADIO	-0.082	0.049	-1.661	0.097
PERMIS	-0.058	0.035	-1.634	0.102
MONEY	-0.011	0.033	-0.325	0.745
DISTANCE	0.041	0.031	1.294	0.196
ALONE	0.028	0.034	0.825	0.410
V511	-0.015	0.022	-0.664	0.507
V531R	0.005	0.015	0.295	0.768
HEALTH	0.868	0.023	36.940	0.000
PURCHASE	0.953	0.020	48.593	0.000
VISIT	0.807	0.028	28.601	0.000
HUSBAND	0.764	0.041	18.785	0.000
HOUSE	0.034	0.034	0.992	0.321
LAND	-0.007	0.019	-0.377	0.706
OUT	0.043	0.035	1.238	0.216
BURNS	-0.013	0.038	-0.353	0.724
NEGLECT	-0.012	0.032	-0.360	0.719
REFUSE	-0.009	0.034	-0.251	0.802
ARGUE	0.008	0.029	0.263	0.792
F4 BY				
EDUC	0.023	0.026	0.883	0.377
TV	-0.016	0.042	-0.388	0.698
NEWS	0.031	0.036	0.847	0.397
RADIO	-0.019	0.037	-0.519	0.604
PERMIS	0.012	0.032	0.360	0.719
MONEY	0.025	0.032	0.778	0.437
DISTANCE	-0.041	0.032	-1.290	0.197
ALONE	0.021	0.035	0.586	0.558
V511	0.028	0.022	1.316	0.188
V531R	-0.027	0.015	-1.847	0.065
HEALTH	-0.035	0.036	-0.991	0.322

PURCHASE	0.002	0.026	0.093	0.926
VISIT	0.060	0.038	1.599	0.110
HUSBAND	-0.017	0.034	-0.507	0.612
HOUSE	-0.003	0.028	-0.107	0.915
LAND	0.004	0.022	0.197	0.844
OUT	0.887	0.021	42.969	0.000
BURNS	0.759	0.029	26.035	0.000
NEGLECT	0.937	0.017	56.668	0.000
REFUSE	0.842	0.024	35.716	0.000
ARGUE	0.898	0.020	43.887	0.000
F5 BY				
EDUC	0.116	0.031	3.735	0.000
TV	-0.040	0.035	-1.150	0.250
NEWS	0.019	0.029	0.636	0.525
RADIO	-0.012	0.029	-0.423	0.672
PERMIS	0.009	0.029	0.317	0.752
MONEY	-0.014	0.026	-0.525	0.600
DISTANCE	-0.037	0.030	-1.263	0.207
ALONE	0.057	0.035	1.640	0.101
V511	0.651	0.068	9.595	0.000
V531R	0.980	0.085	11.527	0.000
HEALTH	0.005	0.028	0.162	0.871
PURCHASE	-0.008	0.021	-0.377	0.706
VISIT	0.029	0.028	1.068	0.286
HUSBAND	-0.039	0.033	-1.178	0.239
HOUSE	0.017	0.023	0.717	0.473
LAND	-0.003	0.018	-0.167	0.867
OUT	-0.005	0.027	-0.204	0.838
BURNS	0.014	0.033	0.425	0.671
NEGLECT	-0.024	0.029	-0.835	0.404
REFUSE	0.012	0.029	0.425	0.671
ARGUE	0.001	0.025	0.051	0.959
F6 BY				
EDUC	-0.104	0.040	-2.601	0.009
TV	-0.036	0.044	-0.821	0.412
NEWS	0.036	0.043	0.851	0.395
RADIO	0.064	0.047	1.375	0.169
PERMIS	0.032	0.040	0.815	0.415
MONEY	0.045	0.038	1.182	0.237
DISTANCE	-0.047	0.040	-1.184	0.236
ALONE	-0.001	0.031	-0.047	0.963
V511	-0.030	0.024	-1.236	0.216
V531R	0.034	0.017	2.039	0.041
HEALTH	-0.001	0.028	-0.036	0.972
PURCHASE	0.036	0.028	1.268	0.205
VISIT	-0.075	0.042	-1.781	0.075
HUSBAND	0.078	0.053	1.472	0.141
HOUSE	0.798	0.062	12.792	0.000
LAND	1.005	0.063	16.032	0.000
OUT	-0.017	0.031	-0.543	0.587
BURNS	-0.042	0.040	-1.062	0.288
NEGLECT	0.037	0.035	1.043	0.297
REFUSE	0.023	0.035	0.648	0.517
ARGUE	-0.002	0.031	-0.053	0.957
F1 ON				
WEALTH	0.444	0.034	13.054	0.000
ETH	-0.462	0.035	-13.047	0.000
TZA	0.385	0.031	12.369	0.000
F2 ON				
WEALTH	0.292	0.040	7.315	0.000

ETH	-0.237	0.042	-5.694	0.000
TZA	-0.007	0.038	-0.169	0.866
F3 ON				
WEALTH	0.086	0.034	2.554	0.011
ETH	0.372	0.042	8.965	0.000
TZA	-0.242	0.035	-6.970	0.000
F4 ON				
WEALTH	0.138	0.032	4.258	0.000
ETH	-0.097	0.045	-2.142	0.032
TZA	-0.091	0.036	-2.531	0.011
F5 ON				
WEALTH	0.165	0.040	4.076	0.000
ETH	-0.089	0.045	-1.959	0.050
TZA	-0.064	0.035	-1.799	0.072
F6 ON				
WEALTH	-0.338	0.040	-8.455	0.000
ETH	0.165	0.047	3.494	0.000
TZA	-0.109	0.044	-2.455	0.014
HB ON				
F1	0.078	0.056	1.409	0.159
F2	0.020	0.041	0.496	0.620
F3	0.029	0.042	0.694	0.488
F4	0.040	0.041	0.962	0.336
F5	-0.030	0.034	-0.881	0.378
F6	0.148	0.044	3.341	0.001
HB ON				
V213	-0.299	0.032	-9.356	0.000
V404	-0.055	0.036	-1.529	0.126
WEALTH	0.053	0.042	1.285	0.199
ETH	0.184	0.044	4.176	0.000
TZA	-0.187	0.041	-4.588	0.000
F2 WITH				
F1	0.110	0.053	2.086	0.037
F3 WITH				
F1	0.056	0.049	1.124	0.261
F2	0.061	0.062	0.989	0.323
F4 WITH				
F1	0.107	0.044	2.451	0.014
F2	0.136	0.050	2.722	0.006
F3	0.162	0.049	3.323	0.001
F5 WITH				
F1	0.148	0.046	3.217	0.001
F2	-0.028	0.044	-0.631	0.528
F3	0.083	0.040	2.042	0.041
F4	0.115	0.043	2.677	0.007
F6 WITH				
F1	0.043	0.061	0.695	0.487
F2	0.007	0.060	0.121	0.904
F3	0.084	0.049	1.701	0.089
F4	-0.101	0.050	-2.021	0.043
F5	-0.016	0.047	-0.347	0.728
Intercepts				

HB	6.543	0.132	49.513	0.000
EDUC	1.845	0.081	22.682	0.000
V511	10.490	0.202	51.839	0.000
V531R	10.397	0.184	56.445	0.000
Thresholds				
TV$1	0.338	0.078	4.317	0.000
NEWS$1	0.670	0.071	9.481	0.000
RADIO$1	-0.322	0.075	-4.288	0.000
PERMIS$1	-0.856	0.083	-10.300	0.000
MONEY$1	-0.269	0.068	-3.946	0.000
DISTANCE$1	-0.233	0.068	-3.433	0.001
ALONE$1	-0.383	0.067	-5.687	0.000
HEALTH$1	-0.464	0.075	-6.207	0.000
PURCHASE$1	-0.078	0.072	-1.084	0.278
VISIT$1	-0.367	0.069	-5.326	0.000
HUSBAND$1	-0.172	0.068	-2.549	0.011
HOUSE$1	0.549	0.072	7.669	0.000
LAND$1	0.669	0.074	9.004	0.000
OUT$1	-0.068	0.075	-0.907	0.364
BURNS$1	-0.648	0.075	-8.654	0.000
NEGLECT$1	0.147	0.078	1.886	0.059
REFUSE$1	-0.490	0.075	-6.556	0.000
ARGUE$1	-0.012	0.077	-0.154	0.878
Residual Variances				
HB	0.826	0.023	36.268	0.000
EDUC	0.526	0.034	15.316	0.000
V511	0.475	0.075	6.365	0.000
V531R	0.061	0.170	0.362	0.717
F1	0.552	0.036	15.234	0.000
F2	0.856	0.028	30.042	0.000
F3	0.836	0.032	26.273	0.000
F4	0.957	0.014	69.559	0.000
F5	0.956	0.017	57.302	0.000
F6	0.860	0.031	27.575	0.000

STDY Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
EDUC	0.623	0.031	20.096	0.000
TV	0.651	0.048	13.625	0.000
NEWS	0.785	0.039	20.157	0.000
RADIO	0.736	0.040	18.320	0.000
PERMIS	0.018	0.037	0.481	0.630
MONEY	0.044	0.036	1.232	0.218
DISTANCE	-0.006	0.029	-0.205	0.838
ALONE	-0.024	0.034	-0.693	0.488
V511	0.200	0.050	4.036	0.000
V531R	-0.037	0.017	-2.184	0.029
HEALTH	0.138	0.053	2.600	0.009
PURCHASE	-0.037	0.017	-2.131	0.033
VISIT	-0.148	0.046	-3.187	0.001
HUSBAND	0.123	0.040	3.051	0.002
HOUSE	-0.090	0.043	-2.117	0.034
LAND	0.052	0.020	2.552	0.011
OUT	-0.068	0.032	-2.135	0.033
BURNS	0.261	0.049	5.368	0.000
NEGLECT	-0.046	0.026	-1.769	0.077
REFUSE	0.121	0.042	2.869	0.004

ARGUE	-0.007	0.024	-0.274	0.784
F2 BY				
EDUC	0.011	0.027	0.403	0.687
TV	0.120	0.056	2.149	0.032
NEWS	-0.109	0.069	-1.595	0.111
RADIO	0.050	0.042	1.192	0.233
PERMIS	0.884	0.026	34.341	0.000
MONEY	0.775	0.030	25.923	0.000
DISTANCE	0.896	0.026	34.758	0.000
ALONE	0.821	0.030	27.469	0.000
V511	-0.021	0.023	-0.891	0.373
V531R	0.012	0.015	0.834	0.404
HEALTH	-0.018	0.029	-0.636	0.525
PURCHASE	0.004	0.026	0.163	0.871
VISIT	0.074	0.040	1.853	0.064
HUSBAND	-0.052	0.058	-0.902	0.367
HOUSE	-0.028	0.033	-0.845	0.398
LAND	0.037	0.028	1.318	0.187
OUT	0.060	0.038	1.607	0.108
BURNS	0.003	0.041	0.082	0.935
NEGLECT	-0.036	0.037	-0.969	0.333
REFUSE	-0.028	0.035	-0.804	0.422
ARGUE	0.019	0.034	0.554	0.579
F3 BY				
EDUC	0.118	0.039	3.042	0.002
TV	0.004	0.036	0.103	0.918
NEWS	0.022	0.036	0.624	0.533
RADIO	-0.082	0.049	-1.661	0.097
PERMIS	-0.058	0.035	-1.634	0.102
MONEY	-0.011	0.033	-0.325	0.745
DISTANCE	0.041	0.031	1.294	0.196
ALONE	0.028	0.034	0.825	0.410
V511	-0.015	0.022	-0.664	0.507
V531R	0.005	0.015	0.295	0.768
HEALTH	0.868	0.023	36.940	0.000
PURCHASE	0.953	0.020	48.593	0.000
VISIT	0.807	0.028	28.601	0.000
HUSBAND	0.764	0.041	18.785	0.000
HOUSE	0.034	0.034	0.992	0.321
LAND	-0.007	0.019	-0.377	0.706
OUT	0.043	0.035	1.238	0.216
BURNS	-0.013	0.038	-0.353	0.724
NEGLECT	-0.012	0.032	-0.360	0.719
REFUSE	-0.009	0.034	-0.251	0.802
ARGUE	0.008	0.029	0.263	0.792
F4 BY				
EDUC	0.023	0.026	0.883	0.377
TV	-0.016	0.042	-0.388	0.698
NEWS	0.031	0.036	0.847	0.397
RADIO	-0.019	0.037	-0.519	0.604
PERMIS	0.012	0.032	0.360	0.719
MONEY	0.025	0.032	0.778	0.437
DISTANCE	-0.041	0.032	-1.290	0.197
ALONE	0.021	0.035	0.586	0.558
V511	0.028	0.022	1.316	0.188
V531R	-0.027	0.015	-1.847	0.065
HEALTH	-0.035	0.036	-0.991	0.322
PURCHASE	0.002	0.026	0.093	0.926
VISIT	0.060	0.038	1.599	0.110
HUSBAND	-0.017	0.034	-0.507	0.612
HOUSE	-0.003	0.028	-0.107	0.915

LAND	0.004	0.022	0.197	0.844
OUT	0.887	0.021	42.969	0.000
BURNS	0.759	0.029	26.035	0.000
NEGLECT	0.937	0.017	56.668	0.000
REFUSE	0.842	0.024	35.716	0.000
ARGUE	0.898	0.020	43.887	0.000
F5 BY				
EDUC	0.116	0.031	3.735	0.000
TV	-0.040	0.035	-1.150	0.250
NEWS	0.019	0.029	0.636	0.525
RADIO	-0.012	0.029	-0.423	0.672
PERMIS	0.009	0.029	0.317	0.752
MONEY	-0.014	0.026	-0.525	0.600
DISTANCE	-0.037	0.030	-1.263	0.207
ALONE	0.057	0.035	1.640	0.101
V511	0.651	0.068	9.595	0.000
V531R	0.980	0.085	11.527	0.000
HEALTH	0.005	0.028	0.162	0.871
PURCHASE	-0.008	0.021	-0.377	0.706
VISIT	0.029	0.028	1.068	0.286
HUSBAND	-0.039	0.033	-1.178	0.239
HOUSE	0.017	0.023	0.717	0.473
LAND	-0.003	0.018	-0.167	0.867
OUT	-0.005	0.027	-0.204	0.838
BURNS	0.014	0.033	0.425	0.671
NEGLECT	-0.024	0.029	-0.835	0.404
REFUSE	0.012	0.029	0.425	0.671
ARGUE	0.001	0.025	0.051	0.959
F6 BY				
EDUC	-0.104	0.040	-2.601	0.009
TV	-0.036	0.044	-0.821	0.412
NEWS	0.036	0.043	0.851	0.395
RADIO	0.064	0.047	1.375	0.169
PERMIS	0.032	0.040	0.815	0.415
MONEY	0.045	0.038	1.182	0.237
DISTANCE	-0.047	0.040	-1.184	0.236
ALONE	-0.001	0.031	-0.047	0.963
V511	-0.030	0.024	-1.236	0.216
V531R	0.034	0.017	2.039	0.041
HEALTH	-0.001	0.028	-0.036	0.972
PURCHASE	0.036	0.028	1.268	0.205
VISIT	-0.075	0.042	-1.781	0.075
HUSBAND	0.078	0.053	1.472	0.141
HOUSE	0.798	0.062	12.792	0.000
LAND	1.005	0.063	16.032	0.000
OUT	-0.017	0.031	-0.543	0.587
BURNS	-0.042	0.040	-1.062	0.288
NEGLECT	0.037	0.035	1.043	0.297
REFUSE	0.023	0.035	0.648	0.517
ARGUE	-0.002	0.031	-0.053	0.957
F1 ON				
WEALTH	0.631	0.047	13.291	0.000
ETH	-0.638	0.048	-13.308	0.000
TZA	0.518	0.041	12.645	0.000
F2 ON				
WEALTH	0.414	0.056	7.367	0.000
ETH	-0.327	0.057	-5.720	0.000
TZA	-0.009	0.052	-0.169	0.866
F3 ON				

WEALTH	0.122	0.048	2.557	0.011
ETH	0.514	0.057	9.058	0.000
TZA	-0.325	0.046	-7.022	0.000
F4 ON				
WEALTH	0.196	0.046	4.270	0.000
ETH	-0.134	0.063	-2.144	0.032
TZA	-0.122	0.048	-2.534	0.011
F5 ON				
WEALTH	0.234	0.057	4.086	0.000
ETH	-0.123	0.063	-1.960	0.050
TZA	-0.086	0.048	-1.799	0.072
F6 ON				
WEALTH	-0.480	0.056	-8.531	0.000
ETH	0.229	0.065	3.501	0.000
TZA	-0.146	0.059	-2.458	0.014
HB ON				
F1	0.078	0.056	1.409	0.159
F2	0.020	0.041	0.496	0.620
F3	0.029	0.042	0.694	0.488
F4	0.040	0.041	0.962	0.336
F5	-0.030	0.034	-0.881	0.378
F6	0.148	0.044	3.341	0.001
HB ON				
V213	-0.738	0.078	-9.465	0.000
V404	-0.112	0.073	-1.530	0.126
WEALTH	0.076	0.059	1.285	0.199
ETH	0.255	0.061	4.187	0.000
TZA	-0.252	0.055	-4.602	0.000
F2 WITH				
F1	0.110	0.053	2.086	0.037
F3 WITH				
F1	0.056	0.049	1.124	0.261
F2	0.061	0.062	0.989	0.323
F4 WITH				
F1	0.107	0.044	2.451	0.014
F2	0.136	0.050	2.722	0.006
F3	0.162	0.049	3.323	0.001
F5 WITH				
F1	0.148	0.046	3.217	0.001
F2	-0.028	0.044	-0.631	0.528
F3	0.083	0.040	2.042	0.041
F4	0.115	0.043	2.677	0.007
F6 WITH				
F1	0.043	0.061	0.695	0.487
F2	0.007	0.060	0.121	0.904
F3	0.084	0.049	1.701	0.089
F4	-0.101	0.050	-2.021	0.043
F5	-0.016	0.047	-0.347	0.728
Intercepts				
HB	6.543	0.132	49.513	0.000
EDUC	1.845	0.081	22.682	0.000
V511	10.490	0.202	51.839	0.000
V531R	10.397	0.184	56.445	0.000

Thresholds				
TV$1	0.338	0.078	4.317	0.000
NEWS$1	0.670	0.071	9.481	0.000
RADIO$1	-0.322	0.075	-4.288	0.000
PERMIS$1	-0.856	0.083	-10.300	0.000
MONEY$1	-0.269	0.068	-3.946	0.000
DISTANCE$1	-0.233	0.068	-3.433	0.001
ALONE$1	-0.383	0.067	-5.687	0.000
HEALTH$1	-0.464	0.075	-6.207	0.000
PURCHASE$1	-0.078	0.072	-1.084	0.278
VISIT$1	-0.367	0.069	-5.326	0.000
HUSBAND$1	-0.172	0.068	-2.549	0.011
HOUSE$1	0.549	0.072	7.669	0.000
LAND$1	0.669	0.074	9.004	0.000
OUT$1	-0.068	0.075	-0.907	0.364
BURNS$1	-0.648	0.075	-8.654	0.000
NEGLECT$1	0.147	0.078	1.886	0.059
REFUSE$1	-0.490	0.075	-6.556	0.000
ARGUE$1	-0.012	0.077	-0.154	0.878
Residual Variances				
HB	0.826	0.023	36.268	0.000
EDUC	0.526	0.034	15.316	0.000
V511	0.475	0.075	6.365	0.000
V531R	0.061	0.170	0.362	0.717
F1	0.552	0.036	15.234	0.000
F2	0.856	0.028	30.042	0.000
F3	0.836	0.032	26.273	0.000
F4	0.957	0.014	69.559	0.000
F5	0.956	0.017	57.302	0.000
F6	0.860	0.031	27.575	0.000

STD Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
EDUC	1.938	0.134	14.513	0.000
TV	0.742	0.065	11.452	0.000
NEWS	0.895	0.059	15.163	0.000
RADIO	0.851	0.059	14.354	0.000
PERMIS	0.019	0.040	0.480	0.631
MONEY	0.047	0.038	1.227	0.220
DISTANCE	-0.006	0.031	-0.205	0.838
ALONE	-0.025	0.036	-0.694	0.488
V511	0.314	0.080	3.943	0.000
V531R	-0.056	0.026	-2.204	0.028
HEALTH	0.145	0.055	2.620	0.009
PURCHASE	-0.040	0.019	-2.142	0.032
VISIT	-0.159	0.051	-3.130	0.002
HUSBAND	0.128	0.042	3.085	0.002
HOUSE	-0.097	0.046	-2.108	0.035
LAND	0.055	0.021	2.568	0.010
OUT	-0.069	0.032	-2.135	0.033
BURNS	0.275	0.052	5.235	0.000
NEGLECT	-0.047	0.026	-1.769	0.077
REFUSE	0.123	0.043	2.843	0.004
ARGUE	-0.007	0.025	-0.274	0.784
F2 BY				
EDUC	0.034	0.085	0.403	0.687

TV	0.137	0.064	2.143	0.032
NEWS	-0.125	0.077	-1.623	0.105
RADIO	0.058	0.048	1.196	0.232
PERMIS	0.942	0.033	28.733	0.000
MONEY	0.814	0.034	24.002	0.000
DISTANCE	0.950	0.032	29.557	0.000
ALONE	0.864	0.035	24.421	0.000
V511	-0.033	0.037	-0.890	0.374
V531R	0.019	0.022	0.834	0.404
HEALTH	-0.019	0.030	-0.636	0.525
PURCHASE	0.005	0.029	0.163	0.871
VISIT	0.079	0.043	1.846	0.065
HUSBAND	-0.054	0.060	-0.901	0.368
HOUSE	-0.030	0.036	-0.844	0.399
LAND	0.040	0.030	1.318	0.187
OUT	0.062	0.038	1.604	0.109
BURNS	0.004	0.044	0.082	0.935
NEGLECT	-0.037	0.038	-0.970	0.332
REFUSE	-0.029	0.036	-0.804	0.421
ARGUE	0.019	0.035	0.554	0.580
F3 BY				
EDUC	0.366	0.120	3.041	0.002
TV	0.004	0.041	0.103	0.918
NEWS	0.025	0.041	0.626	0.531
RADIO	-0.095	0.057	-1.663	0.096
PERMIS	-0.062	0.038	-1.630	0.103
MONEY	-0.011	0.035	-0.325	0.745
DISTANCE	0.043	0.033	1.294	0.196
ALONE	0.029	0.036	0.826	0.409
V511	-0.023	0.034	-0.665	0.506
V531R	0.007	0.023	0.295	0.768
HEALTH	0.911	0.030	30.174	0.000
PURCHASE	1.042	0.031	33.844	0.000
VISIT	0.869	0.035	24.809	0.000
HUSBAND	0.794	0.046	17.249	0.000
HOUSE	0.036	0.036	0.992	0.321
LAND	-0.008	0.020	-0.377	0.706
OUT	0.044	0.036	1.237	0.216
BURNS	-0.014	0.040	-0.353	0.724
NEGLECT	-0.012	0.033	-0.360	0.719
REFUSE	-0.009	0.035	-0.251	0.802
ARGUE	0.008	0.029	0.263	0.792
F4 BY				
EDUC	0.072	0.082	0.882	0.378
TV	-0.018	0.047	-0.388	0.698
NEWS	0.035	0.041	0.844	0.399
RADIO	-0.022	0.043	-0.519	0.604
PERMIS	0.012	0.034	0.360	0.719
MONEY	0.026	0.034	0.777	0.437
DISTANCE	-0.044	0.034	-1.291	0.197
ALONE	0.022	0.037	0.586	0.558
V511	0.045	0.034	1.312	0.189
V531R	-0.041	0.022	-1.852	0.064
HEALTH	-0.037	0.037	-0.990	0.322
PURCHASE	0.003	0.028	0.093	0.926
VISIT	0.065	0.040	1.600	0.110
HUSBAND	-0.018	0.035	-0.507	0.612
HOUSE	-0.003	0.030	-0.107	0.915
LAND	0.005	0.023	0.197	0.844
OUT	0.904	0.021	42.590	0.000
BURNS	0.799	0.030	27.020	0.000
NEGLECT	0.949	0.018	54.213	0.000

REFUSE	0.862	0.025	34.454	0.000
ARGUE	0.915	0.021	43.645	0.000
F5 BY				
EDUC	0.360	0.099	3.626	0.000
TV	-0.046	0.040	-1.150	0.250
NEWS	0.021	0.034	0.635	0.525
RADIO	-0.014	0.033	-0.422	0.673
PERMIS	0.010	0.031	0.317	0.751
MONEY	-0.015	0.028	-0.525	0.599
DISTANCE	-0.040	0.031	-1.266	0.206
ALONE	0.060	0.037	1.638	0.101
V511	1.022	0.107	9.561	0.000
V531R	1.498	0.141	10.605	0.000
HEALTH	0.005	0.029	0.162	0.871
PURCHASE	-0.009	0.023	-0.377	0.706
VISIT	0.032	0.030	1.067	0.286
HUSBAND	-0.041	0.035	-1.178	0.239
HOUSE	0.018	0.025	0.717	0.473
LAND	-0.003	0.019	-0.167	0.867
OUT	-0.006	0.027	-0.204	0.838
BURNS	0.015	0.034	0.425	0.671
NEGLECT	-0.024	0.029	-0.835	0.403
REFUSE	0.013	0.030	0.425	0.671
ARGUE	0.001	0.026	0.051	0.959
F6 BY				
EDUC	-0.323	0.124	-2.598	0.009
TV	-0.041	0.050	-0.818	0.413
NEWS	0.041	0.049	0.847	0.397
RADIO	0.075	0.054	1.386	0.166
PERMIS	0.034	0.042	0.817	0.414
MONEY	0.048	0.040	1.186	0.236
DISTANCE	-0.050	0.042	-1.182	0.237
ALONE	-0.002	0.033	-0.047	0.963
V511	-0.048	0.039	-1.231	0.218
V531R	0.052	0.025	2.040	0.041
HEALTH	-0.001	0.029	-0.036	0.972
PURCHASE	0.039	0.031	1.267	0.205
VISIT	-0.080	0.045	-1.770	0.077
HUSBAND	0.081	0.055	1.477	0.140
HOUSE	0.858	0.073	11.688	0.000
LAND	1.064	0.072	14.850	0.000
OUT	-0.017	0.031	-0.542	0.588
BURNS	-0.045	0.042	-1.061	0.289
NEGLECT	0.037	0.036	1.044	0.297
REFUSE	0.023	0.036	0.648	0.517
ARGUE	-0.002	0.032	-0.053	0.957
F1 ON				
WEALTH	0.631	0.047	13.291	0.000
ETH	-0.638	0.048	-13.308	0.000
TZA	0.518	0.041	12.645	0.000
F2 ON				
WEALTH	0.414	0.056	7.367	0.000
ETH	-0.327	0.057	-5.720	0.000
TZA	-0.009	0.052	-0.169	0.866
F3 ON				
WEALTH	0.122	0.048	2.557	0.011
ETH	0.514	0.057	9.058	0.000
TZA	-0.325	0.046	-7.022	0.000

F4 ON				
WEALTH	0.196	0.046	4.270	0.000
ETH	-0.134	0.063	-2.144	0.032
TZA	-0.122	0.048	-2.534	0.011
F5 ON				
WEALTH	0.234	0.057	4.086	0.000
ETH	-0.123	0.063	-1.960	0.050
TZA	-0.086	0.048	-1.799	0.072
F6 ON				
WEALTH	-0.480	0.056	-8.531	0.000
ETH	0.229	0.065	3.501	0.000
TZA	-0.146	0.059	-2.458	0.014
HB ON				
F1	0.149	0.106	1.408	0.159
F2	0.039	0.078	0.496	0.620
F3	0.055	0.079	0.694	0.488
F4	0.076	0.079	0.959	0.338
F5	-0.058	0.066	-0.881	0.378
F6	0.282	0.084	3.347	0.001
HB ON				
V213	-1.405	0.158	-8.912	0.000
V404	-0.213	0.140	-1.524	0.128
WEALTH	0.145	0.112	1.285	0.199
ETH	0.485	0.118	4.107	0.000
TZA	-0.480	0.108	-4.457	0.000
F2 WITH				
F1	0.110	0.053	2.086	0.037
F3 WITH				
F1	0.056	0.049	1.124	0.261
F2	0.061	0.062	0.989	0.323
F4 WITH				
F1	0.107	0.044	2.451	0.014
F2	0.136	0.050	2.722	0.006
F3	0.162	0.049	3.323	0.001
F5 WITH				
F1	0.148	0.046	3.217	0.001
F2	-0.028	0.044	-0.631	0.528
F3	0.083	0.040	2.042	0.041
F4	0.115	0.043	2.677	0.007
F6 WITH				
F1	0.043	0.061	0.695	0.487
F2	0.007	0.060	0.121	0.904
F3	0.084	0.049	1.701	0.089
F4	-0.101	0.050	-2.021	0.043
F5	-0.016	0.047	-0.347	0.728
Intercepts				
HB	12.467	0.107	117.050	0.000
EDUC	5.744	0.164	34.952	0.000
V511	16.479	0.090	184.033	0.000
V531R	15.899	0.086	183.863	0.000
Thresholds				
TV$1	0.385	0.087	4.419	0.000
NEWS$1	0.764	0.082	9.270	0.000

RADIO$1	-0.372	0.087	-4.277	0.000
PERMIS$1	-0.913	0.092	-9.952	0.000
MONEY$1	-0.283	0.072	-3.920	0.000
DISTANCE$1	-0.247	0.073	-3.398	0.001
ALONE$1	-0.403	0.072	-5.641	0.000
HEALTH$1	-0.487	0.079	-6.157	0.000
PURCHASE$1	-0.085	0.079	-1.082	0.279
VISIT$1	-0.395	0.074	-5.318	0.000
HUSBAND$1	-0.179	0.070	-2.550	0.011
HOUSE$1	0.590	0.078	7.534	0.000
LAND$1	0.709	0.080	8.870	0.000
OUT$1	-0.069	0.076	-0.906	0.365
BURNS$1	-0.682	0.081	-8.468	0.000
NEGLECT$1	0.149	0.079	1.891	0.059
REFUSE$1	-0.501	0.077	-6.497	0.000
ARGUE$1	-0.012	0.078	-0.154	0.878

Residual Variances

HB	2.999	0.125	23.922	0.000
EDUC	5.094	0.365	13.973	0.000
V511	1.173	0.186	6.291	0.000
V531R	0.144	0.395	0.364	0.716
F1	0.552	0.036	15.234	0.000
F2	0.856	0.028	30.042	0.000
F3	0.836	0.032	26.273	0.000
F4	0.957	0.014	69.559	0.000
F5	0.956	0.017	57.302	0.000
F6	0.860	0.031	27.575	0.000

R-SQUARE

Observed Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Residual Variance
HB	0.174	0.023	7.635	0.000	
EDUC	0.474	0.034	13.825	0.000	
TV	0.481	0.054	8.876	0.000	0.673
NEWS	0.579	0.056	10.367	0.000	0.546
RADIO	0.563	0.047	11.889	0.000	0.585
PERMIS	0.792	0.043	18.603	0.000	0.236
MONEY	0.621	0.041	15.282	0.000	0.418
DISTANCE	0.798	0.040	19.954	0.000	0.227
ALONE	0.680	0.042	16.233	0.000	0.355
V511	0.525	0.075	7.030	0.000	
V531R	0.939	0.170	5.534	0.000	
HEALTH	0.733	0.035	20.856	0.000	0.294
PURCHASE	0.927	0.033	27.676	0.000	0.087
VISIT	0.713	0.038	18.697	0.000	0.333
HUSBAND	0.583	0.051	11.510	0.000	0.451
HOUSE	0.688	0.088	7.842	0.000	0.360
LAND	0.982	0.126	7.819	0.000	0.020
OUT	0.813	0.030	27.289	0.000	0.194
BURNS	0.725	0.039	18.660	0.000	0.305
NEGLECT	0.840	0.028	30.086	0.000	0.164
REFUSE	0.739	0.037	20.206	0.000	0.273
ARGUE	0.815	0.031	25.908	0.000	0.192

Latent Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1	0.448	0.036	12.369	0.000
F2	0.144	0.028	5.057	0.000
F3	0.164	0.032	5.146	0.000

F4	0.043	0.014	3.155	0.002
F5	0.044	0.017	2.644	0.008
F6	0.140	0.031	4.471	0.000

CONFIDENCE INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
F1 BY							
EDUC	1.175	1.239	1.271	1.440	1.609	1.641	1.705
TV	0.430	0.459	0.474	0.551	0.628	0.643	0.672
NEWS	0.553	0.580	0.593	0.665	0.736	0.749	0.776
RADIO	0.526	0.551	0.564	0.632	0.701	0.714	0.739
PERMIS	-0.062	-0.044	-0.034	0.014	0.063	0.072	0.090
MONEY	-0.038	-0.021	-0.012	0.035	0.081	0.090	0.107
DISTANCE	-0.065	-0.050	-0.043	-0.005	0.033	0.041	0.055
ALONE	-0.088	-0.071	-0.063	-0.019	0.026	0.034	0.050
V511	0.079	0.116	0.135	0.233	0.332	0.351	0.388
V531R	-0.090	-0.079	-0.073	-0.042	-0.011	-0.005	0.006
HEALTH	0.001	0.027	0.040	0.108	0.176	0.189	0.214
PURCHASE	-0.065	-0.057	-0.052	-0.030	-0.007	-0.003	0.005
VISIT	-0.216	-0.192	-0.180	-0.118	-0.056	-0.044	-0.021
HUSBAND	0.016	0.035	0.045	0.095	0.146	0.156	0.175
HOUSE	-0.160	-0.139	-0.128	-0.072	-0.016	-0.005	0.016
LAND	0.000	0.009	0.014	0.041	0.067	0.072	0.082
OUT	-0.113	-0.098	-0.091	-0.051	-0.012	-0.004	0.010
BURNS	0.105	0.129	0.141	0.204	0.267	0.279	0.303
NEGLECT	-0.085	-0.073	-0.067	-0.035	-0.002	0.004	0.016
REFUSE	0.009	0.029	0.039	0.092	0.144	0.155	0.174
ARGUE	-0.053	-0.041	-0.036	-0.005	0.025	0.031	0.043
F2 BY							
EDUC	-0.170	-0.122	-0.097	0.031	0.160	0.185	0.233
TV	-0.025	0.011	0.030	0.127	0.223	0.242	0.278
NEWS	-0.298	-0.254	-0.232	-0.115	0.001	0.023	0.067
RADIO	-0.061	-0.034	-0.020	0.053	0.126	0.140	0.168
PERMIS	0.803	0.820	0.828	0.872	0.916	0.924	

0.941						
MONEY	0.678	0.696	0.705	0.753	0.801	0.810
0.828						
DISTANCE	0.811	0.827	0.835	0.879	0.923	0.931
0.948						
ALONE	0.721	0.739	0.749	0.799	0.849	0.859
0.878						
V511	-0.118	-0.097	-0.086	-0.030	0.026	0.036
0.057						
V531R	-0.036	-0.023	-0.017	0.017	0.051	0.058
0.071						
HEALTH	-0.089	-0.072	-0.063	-0.018	0.028	0.037
0.054						
PURCHASE	-0.064	-0.048	-0.039	0.004	0.048	0.056
0.072						
VISIT	-0.029	-0.004	0.008	0.074	0.139	0.151
0.176						
HUSBAND	-0.193	-0.159	-0.142	-0.050	0.041	0.059
0.093						
HOUSE	-0.114	-0.093	-0.083	-0.028	0.027	0.037
0.058						
LAND	-0.035	-0.018	-0.009	0.037	0.083	0.091
0.109						
OUT	-0.035	-0.013	-0.002	0.057	0.115	0.127
0.149						
BURNS	-0.101	-0.076	-0.063	0.003	0.070	0.082
0.107						
NEGLECT	-0.124	-0.102	-0.091	-0.034	0.023	0.034
0.056						
REFUSE	-0.112	-0.092	-0.081	-0.027	0.028	0.038
0.059						
ARGUE	-0.065	-0.045	-0.035	0.018	0.070	0.081
0.100						
F3 BY						
EDUC	0.049	0.118	0.152	0.335	0.517	0.552
0.620						
TV	-0.093	-0.069	-0.058	0.004	0.065	0.077
0.100						
NEWS	-0.072	-0.050	-0.038	0.023	0.084	0.096
0.119						
RADIO	-0.220	-0.188	-0.172	-0.086	-0.001	0.015
0.047						
PERMIS	-0.145	-0.124	-0.113	-0.056	0.000	0.011
0.032						
MONEY	-0.092	-0.072	-0.062	-0.010	0.042	0.052
0.071						
DISTANCE	-0.039	-0.020	-0.010	0.039	0.089	0.099
0.117						
ALONE	-0.057	-0.037	-0.027	0.027	0.080	0.091
0.111						
V511	-0.102	-0.082	-0.072	-0.021	0.031	0.041
0.060						
V531R	-0.049	-0.036	-0.029	0.006	0.042	0.048
0.062						
HEALTH	0.769	0.785	0.792	0.833	0.874	0.882
0.897						
PURCHASE	0.897	0.910	0.917	0.953	0.989	0.995
1.009						
VISIT	0.721	0.738	0.747	0.795	0.842	0.851
0.869						
HUSBAND	0.616	0.642	0.656	0.726	0.797	0.811
0.837						
HOUSE	-0.053	-0.032	-0.022	0.033	0.088	0.098

0.119						
LAND	-0.054	-0.043	-0.037	-0.007	0.023	0.029
0.041						
OUT	-0.044	-0.023	-0.013	0.040	0.094	0.104
0.124						
BURNS	-0.106	-0.084	-0.072	-0.013	0.047	0.058
0.081						
NEGLECT	-0.088	-0.069	-0.060	-0.011	0.038	0.048
0.066						
REFUSE	-0.090	-0.071	-0.061	-0.008	0.045	0.055
0.074						
ARGUE	-0.062	-0.045	-0.037	0.007	0.051	0.059
0.076						
F4 BY						
EDUC	-0.136	-0.087	-0.061	0.071	0.203	0.228
0.278						
TV	-0.137	-0.109	-0.094	-0.018	0.058	0.073
0.101						
NEWS	-0.070	-0.045	-0.032	0.034	0.100	0.113
0.138						
RADIO	-0.131	-0.105	-0.091	-0.022	0.048	0.061
0.087						
PERMIS	-0.075	-0.054	-0.043	0.012	0.068	0.078
0.099						
MONEY	-0.059	-0.039	-0.028	0.026	0.079	0.090
0.110						
DISTANCE	-0.127	-0.107	-0.097	-0.043	0.012	0.022
0.042						
ALONE	-0.072	-0.050	-0.039	0.021	0.081	0.093
0.115						
V511	-0.042	-0.022	-0.011	0.044	0.098	0.109
0.129						
V531R	-0.097	-0.083	-0.076	-0.040	-0.004	0.002
0.016						
HEALTH	-0.130	-0.108	-0.096	-0.036	0.024	0.035
0.058						
PURCHASE	-0.069	-0.052	-0.043	0.003	0.048	0.057
0.074						
VISIT	-0.039	-0.014	-0.002	0.063	0.128	0.141
0.165						
HUSBAND	-0.106	-0.085	-0.074	-0.017	0.039	0.050
0.071						
HOUSE	-0.078	-0.060	-0.051	-0.003	0.045	0.054
0.072						
LAND	-0.053	-0.039	-0.032	0.004	0.041	0.048
0.062						
OUT	0.832	0.844	0.851	0.884	0.917	0.923
0.936						
BURNS	0.707	0.725	0.734	0.781	0.829	0.838
0.855						
NEGLECT	0.886	0.896	0.901	0.928	0.955	0.961
0.971						
REFUSE	0.783	0.797	0.804	0.843	0.881	0.888
0.903						
ARGUE	0.843	0.856	0.862	0.895	0.929	0.935
0.947						
F5 BY						
EDUC	0.104	0.163	0.194	0.352	0.510	0.540
0.599						
TV	-0.145	-0.121	-0.109	-0.045	0.019	0.032
0.055						
NEWS	-0.064	-0.043	-0.033	0.021	0.075	0.085

0.105						
RADIO	-0.098	-0.078	-0.067	-0.014	0.040	0.050
0.070						
PERMIS	-0.068	-0.049	-0.040	0.010	0.059	0.069
0.087						
MONEY	-0.084	-0.067	-0.059	-0.014	0.030	0.039
0.056						
DISTANCE	-0.118	-0.099	-0.089	-0.039	0.012	0.021
0.040						
ALONE	-0.033	-0.011	0.000	0.059	0.117	0.129
0.151						
V511	0.741	0.802	0.834	1.000	1.165	1.197
1.259						
V531R	1.093	1.182	1.228	1.465	1.702	1.748
1.837						
HEALTH	-0.069	-0.051	-0.042	0.005	0.052	0.061
0.078						
PURCHASE	-0.066	-0.053	-0.045	-0.008	0.028	0.036
0.049						
VISIT	-0.044	-0.026	-0.017	0.031	0.079	0.088
0.106						
HUSBAND	-0.128	-0.107	-0.096	-0.040	0.016	0.027
0.048						
HOUSE	-0.045	-0.030	-0.023	0.017	0.057	0.065
0.080						
LAND	-0.052	-0.040	-0.034	-0.003	0.028	0.034
0.045						
OUT	-0.074	-0.058	-0.049	-0.005	0.038	0.047
0.063						
BURNS	-0.072	-0.052	-0.041	0.014	0.070	0.080
0.101						
NEGLECT	-0.097	-0.079	-0.070	-0.024	0.023	0.032
0.049						
REFUSE	-0.063	-0.045	-0.036	0.012	0.061	0.070
0.088						
ARGUE	-0.063	-0.048	-0.040	0.001	0.042	0.050
0.066						
F6 BY						
EDUC	-0.596	-0.525	-0.489	-0.300	-0.111	-0.075
-0.004						
TV	-0.159	-0.130	-0.115	-0.038	0.039	0.053
0.082						
NEWS	-0.078	-0.050	-0.036	0.038	0.113	0.127
0.155						
RADIO	-0.060	-0.029	-0.013	0.069	0.151	0.167
0.198						
PERMIS	-0.069	-0.045	-0.033	0.032	0.096	0.109
0.133						
MONEY	-0.052	-0.029	-0.017	0.044	0.105	0.117
0.140						
DISTANCE	-0.147	-0.123	-0.110	-0.046	0.018	0.030
0.054						
ALONE	-0.079	-0.061	-0.051	-0.001	0.048	0.058
0.076						
V511	-0.136	-0.114	-0.103	-0.044	0.015	0.026
0.048						
V531R	-0.012	0.002	0.009	0.048	0.087	0.094
0.109						
HEALTH	-0.071	-0.055	-0.046	-0.001	0.044	0.053
0.069						
PURCHASE	-0.038	-0.020	-0.011	0.037	0.084	0.093
0.111						
VISIT	-0.183	-0.157	-0.144	-0.075	-0.005	0.008

0.034						
HUSBAND	-0.057	-0.025	-0.009	0.076	0.160	0.176
0.208						
HOUSE	0.636	0.674	0.694	0.796	0.898	0.917
0.956						
LAND	0.804	0.848	0.870	0.987	1.105	1.127
1.171						
OUT	-0.091	-0.073	-0.064	-0.016	0.032	0.041
0.059						
BURNS	-0.142	-0.118	-0.106	-0.041	0.023	0.035
0.059						
NEGLECT	-0.051	-0.030	-0.020	0.035	0.089	0.100
0.120						
REFUSE	-0.064	-0.043	-0.033	0.021	0.076	0.086
0.107						
ARGUE	-0.078	-0.059	-0.050	-0.002	0.047	0.056
0.074						
F1 ON						
WEALTH	0.642	0.692	0.717	0.849	0.982	1.007
1.057						
ETH	-1.070	-1.019	-0.994	-0.859	-0.724	-0.698
-0.648						
TZA	0.518	0.561	0.583	0.697	0.812	0.834
0.877						
F2 ON						
WEALTH	0.276	0.317	0.338	0.448	0.558	0.579
0.620						
ETH	-0.522	-0.482	-0.461	-0.354	-0.246	-0.226
-0.185						
TZA	-0.154	-0.119	-0.101	-0.009	0.083	0.100
0.135						
F3 ON						
WEALTH	-0.001	0.031	0.048	0.134	0.220	0.236
0.269						
ETH	0.377	0.421	0.444	0.562	0.681	0.703
0.748						
TZA	-0.499	-0.465	-0.447	-0.356	-0.265	-0.247
-0.213						
F4 ON						
WEALTH	0.077	0.106	0.121	0.200	0.279	0.294
0.323						
ETH	-0.303	-0.264	-0.243	-0.137	-0.031	-0.011
0.029						
TZA	-0.252	-0.222	-0.206	-0.125	-0.043	-0.028
0.003						
F5 ON						
WEALTH	0.084	0.121	0.140	0.240	0.339	0.358
0.396						
ETH	-0.292	-0.252	-0.232	-0.126	-0.019	0.001
0.041						
TZA	-0.213	-0.183	-0.168	-0.088	-0.008	0.008
0.038						
F6 ON						
WEALTH	-0.695	-0.652	-0.630	-0.517	-0.404	-0.382
-0.340						
ETH	0.059	0.104	0.127	0.246	0.366	0.389
0.434						
TZA	-0.326	-0.285	-0.265	-0.157	-0.050	-0.029

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   0.011

 HB       ON
    F1              -0.091      -0.042      -0.018       0.111       0.240       0.264
   0.312
    F2              -0.151      -0.106      -0.083       0.036       0.155       0.178
   0.222
    F3              -0.136      -0.092      -0.069       0.050       0.169       0.192
   0.237
    F4              -0.125      -0.077      -0.053       0.074       0.201       0.225
   0.272
    F5              -0.222      -0.182      -0.162      -0.056       0.049       0.069
   0.109
    F6               0.060       0.108       0.133       0.262       0.390       0.415
   0.463

 HB       ON
    V213            -1.812      -1.715      -1.665      -1.405      -1.146      -1.096
  -0.999
    V404            -0.573      -0.487      -0.443      -0.213       0.017       0.061
   0.147
    WEALTH          -0.145      -0.076      -0.040       0.145       0.330       0.365
   0.434
    ETH              0.181       0.254       0.291       0.485       0.679       0.717
   0.789
    TZA             -0.757      -0.691      -0.657      -0.480      -0.303      -0.269
  -0.203

 F2       WITH
    F1              -0.026       0.007       0.023       0.110       0.196       0.213
   0.245

 F3       WITH
    F1              -0.072      -0.041      -0.026       0.056       0.137       0.152
   0.183
    F2              -0.098      -0.060      -0.041       0.061       0.163       0.182
   0.220

 F4       WITH
    F1              -0.005       0.021       0.035       0.107       0.179       0.193
   0.219
    F2               0.007       0.038       0.054       0.136       0.219       0.234
   0.265
    F3               0.036       0.067       0.082       0.162       0.243       0.258
   0.288

 F5       WITH
    F1               0.030       0.058       0.072       0.148       0.224       0.238
   0.267
    F2              -0.142      -0.114      -0.100      -0.028       0.045       0.059
   0.086
    F3              -0.022       0.003       0.016       0.083       0.149       0.162
   0.187
    F4               0.004       0.031       0.044       0.115       0.185       0.198
   0.225

 F6       WITH
    F1              -0.115      -0.077      -0.058       0.043       0.143       0.163
   0.200
    F2              -0.146      -0.110      -0.091       0.007       0.105       0.124
   0.161
    F3              -0.043      -0.013       0.003       0.084       0.165       0.181
   0.211
    F4              -0.231      -0.200      -0.184      -0.101      -0.019      -0.003
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0.028						
F5	-0.136	-0.108	-0.093	-0.016	0.061	0.075
0.104						
Intercepts						
HB	12.193	12.259	12.292	12.467	12.643	12.676
12.742						
EDUC	5.320	5.422	5.473	5.744	6.014	6.066
6.167						
V511	16.248	16.303	16.332	16.479	16.626	16.655
16.710						
V531R	15.676	15.730	15.757	15.899	16.041	16.069
16.122						
Thresholds						
TV$1	0.161	0.214	0.242	0.385	0.529	0.556
0.610						
NEWS$1	0.552	0.602	0.628	0.764	0.899	0.925
0.976						
RADIO$1	-0.597	-0.543	-0.516	-0.372	-0.229	-0.202
-0.148						
PERMIS$1	-1.149	-1.092	-1.064	-0.913	-0.762	-0.733
-0.676						
MONEY$1	-0.468	-0.424	-0.401	-0.283	-0.164	-0.141
-0.097						
DISTANCE	-0.435	-0.390	-0.367	-0.247	-0.128	-0.105
-0.060						
ALONE$1	-0.588	-0.544	-0.521	-0.403	-0.286	-0.263
-0.219						
HEALTH$1	-0.691	-0.642	-0.617	-0.487	-0.357	-0.332
-0.283						
PURCHASE	-0.288	-0.239	-0.214	-0.085	0.044	0.069
0.117						
VISIT$1	-0.587	-0.541	-0.518	-0.395	-0.273	-0.250
-0.204						
HUSBAND$	-0.360	-0.317	-0.295	-0.179	-0.064	-0.041
0.002						
HOUSE$1	0.388	0.436	0.461	0.590	0.719	0.743
0.791						
LAND$1	0.503	0.553	0.578	0.709	0.841	0.866
0.915						
OUT$1	-0.265	-0.218	-0.194	-0.069	0.056	0.080
0.127						
BURNS$1	-0.889	-0.839	-0.814	-0.682	-0.549	-0.524
-0.474						
NEGLECT$	-0.054	-0.005	0.019	0.149	0.278	0.303
0.352						
REFUSE$1	-0.700	-0.653	-0.628	-0.501	-0.374	-0.350
-0.303						
ARGUE$1	-0.213	-0.165	-0.140	-0.012	0.116	0.141
0.189						
Residual Variances						
HB	2.676	2.753	2.793	2.999	3.205	3.245
3.322						
EDUC	4.155	4.379	4.494	5.094	5.694	5.808
6.033						
V511	0.693	0.807	0.866	1.173	1.479	1.538
1.653						
V531R	-0.874	-0.630	-0.506	0.144	0.794	0.918
1.161						
F1	1.000	1.000	1.000	1.000	1.000	1.000
1.000						
F2	1.000	1.000	1.000	1.000	1.000	1.000

1.000						
F3	1.000	1.000	1.000	1.000	1.000	1.000
1.000						
F4	1.000	1.000	1.000	1.000	1.000	1.000
1.000						
F5	1.000	1.000	1.000	1.000	1.000	1.000
1.000						
F6	1.000	1.000	1.000	1.000	1.000	1.000
1.000						

CONFIDENCE INTERVALS OF STANDARDIZED MODEL RESULTS

STDYX Standardization

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%
Upper .5%						
F1 BY						
EDUC	0.543	0.562	0.572	0.623	0.674	0.683
0.702						
TV	0.528	0.558	0.573	0.651	0.730	0.745
0.775						
NEWS	0.685	0.709	0.721	0.785	0.849	0.861
0.885						
RADIO	0.632	0.657	0.670	0.736	0.802	0.814
0.839						
PERMIS	-0.078	-0.055	-0.043	0.018	0.079	0.091
0.113						
MONEY	-0.048	-0.026	-0.015	0.044	0.104	0.115
0.137						
DISTANCE	-0.082	-0.064	-0.055	-0.006	0.042	0.052
0.070						
ALONE	-0.112	-0.091	-0.080	-0.024	0.033	0.044
0.065						
V511	0.072	0.103	0.118	0.200	0.281	0.297
0.328						
V531R	-0.080	-0.070	-0.065	-0.037	-0.009	-0.004
0.007						
HEALTH	0.001	0.034	0.051	0.138	0.225	0.242
0.275						
PURCHASE	-0.081	-0.070	-0.065	-0.037	-0.008	-0.003
0.008						
VISIT	-0.267	-0.238	-0.224	-0.148	-0.071	-0.057
-0.028						
HUSBAND	0.019	0.044	0.057	0.123	0.190	0.203
0.228						
HOUSE	-0.200	-0.174	-0.160	-0.090	-0.020	-0.007
0.020						
LAND	0.000	0.012	0.018	0.052	0.085	0.092
0.104						
OUT	-0.150	-0.130	-0.120	-0.068	-0.016	-0.006
0.014						
BURNS	0.136	0.166	0.181	0.261	0.341	0.357
0.386						
NEGLECT	-0.113	-0.097	-0.089	-0.046	-0.003	0.005
0.021						
REFUSE	0.012	0.038	0.051	0.121	0.190	0.203
0.229						
ARGUE	-0.070	-0.055	-0.047	-0.007	0.034	0.041
0.056						
F2 BY						

EDUC	-0.059	-0.042	-0.034	0.011	0.056	0.064
0.081						
TV	-0.024	0.011	0.028	0.120	0.212	0.230
0.264						
NEWS	-0.286	-0.244	-0.222	-0.109	0.003	0.025
0.067						
RADIO	-0.058	-0.032	-0.019	0.050	0.118	0.132
0.157						
PERMIS	0.818	0.834	0.842	0.884	0.927	0.935
0.951						
MONEY	0.698	0.716	0.726	0.775	0.824	0.833
0.852						
DISTANCE	0.829	0.845	0.853	0.896	0.938	0.946
0.962						
ALONE	0.744	0.762	0.772	0.821	0.870	0.879
0.898						
V511	-0.081	-0.067	-0.059	-0.021	0.018	0.025
0.039						
V531R	-0.025	-0.016	-0.012	0.012	0.036	0.041
0.050						
HEALTH	-0.092	-0.074	-0.065	-0.018	0.029	0.038
0.055						
PURCHASE	-0.063	-0.047	-0.039	0.004	0.047	0.055
0.072						
VISIT	-0.029	-0.004	0.008	0.074	0.139	0.152
0.176						
HUSBAND	-0.201	-0.165	-0.147	-0.052	0.043	0.061
0.096						
HOUSE	-0.114	-0.093	-0.083	-0.028	0.027	0.037
0.058						
LAND	-0.036	-0.018	-0.009	0.037	0.084	0.093
0.111						
OUT	-0.036	-0.013	-0.001	0.060	0.122	0.134
0.157						
BURNS	-0.103	-0.078	-0.065	0.003	0.072	0.085
0.110						
NEGLECT	-0.132	-0.109	-0.097	-0.036	0.025	0.037
0.060						
REFUSE	-0.119	-0.097	-0.086	-0.028	0.030	0.041
0.062						
ARGUE	-0.069	-0.048	-0.037	0.019	0.075	0.085
0.106						
F3 BY						
EDUC	0.018	0.042	0.054	0.118	0.181	0.193
0.217						
TV	-0.089	-0.067	-0.055	0.004	0.063	0.074
0.096						
NEWS	-0.070	-0.048	-0.037	0.022	0.081	0.092
0.115						
RADIO	-0.208	-0.178	-0.163	-0.082	-0.001	0.015
0.045						
PERMIS	-0.149	-0.127	-0.116	-0.058	0.000	0.012
0.033						
MONEY	-0.096	-0.075	-0.065	-0.011	0.044	0.054
0.074						
DISTANCE	-0.040	-0.021	-0.011	0.041	0.092	0.102
0.121						
ALONE	-0.059	-0.038	-0.028	0.028	0.084	0.094
0.115						
V511	-0.071	-0.057	-0.050	-0.015	0.021	0.028
0.042						
V531R	-0.035	-0.026	-0.021	0.005	0.030	0.035
0.044						

HEALTH	0.807	0.822	0.829	0.868	0.906	0.914
0.928						
PURCHASE	0.902	0.915	0.921	0.953	0.985	0.991
1.004						
VISIT	0.734	0.751	0.760	0.807	0.853	0.862
0.879						
HUSBAND	0.659	0.684	0.697	0.764	0.831	0.844
0.869						
HOUSE	-0.054	-0.033	-0.022	0.034	0.089	0.100
0.121						
LAND	-0.056	-0.044	-0.038	-0.007	0.024	0.030
0.042						
OUT	-0.047	-0.025	-0.014	0.043	0.101	0.112
0.134						
BURNS	-0.110	-0.087	-0.075	-0.013	0.049	0.061
0.084						
NEGLECT	-0.095	-0.075	-0.065	-0.012	0.041	0.052
0.071						
REFUSE	-0.096	-0.075	-0.065	-0.009	0.048	0.058
0.079						
ARGUE	-0.066	-0.049	-0.040	0.008	0.055	0.064
0.081						
F4 BY						
EDUC	-0.045	-0.028	-0.020	0.023	0.067	0.075
0.091						
TV	-0.123	-0.098	-0.085	-0.016	0.052	0.065
0.091						
NEWS	-0.062	-0.040	-0.029	0.031	0.090	0.101
0.123						
RADIO	-0.116	-0.093	-0.081	-0.019	0.042	0.054
0.077						
PERMIS	-0.072	-0.052	-0.042	0.012	0.065	0.075
0.095						
MONEY	-0.057	-0.038	-0.028	0.025	0.077	0.087
0.107						
DISTANCE	-0.123	-0.103	-0.093	-0.041	0.011	0.021
0.041						
ALONE	-0.070	-0.049	-0.037	0.021	0.079	0.090
0.112						
V511	-0.027	-0.014	-0.007	0.028	0.064	0.071
0.084						
V531R	-0.065	-0.056	-0.051	-0.027	-0.003	0.002
0.011						
HEALTH	-0.127	-0.105	-0.094	-0.035	0.023	0.034
0.056						
PURCHASE	-0.065	-0.049	-0.040	0.002	0.045	0.053
0.069						
VISIT	-0.037	-0.014	-0.002	0.060	0.122	0.134
0.157						
HUSBAND	-0.104	-0.084	-0.073	-0.017	0.039	0.049
0.070						
HOUSE	-0.074	-0.057	-0.048	-0.003	0.042	0.051
0.068						
LAND	-0.051	-0.038	-0.031	0.004	0.040	0.047
0.060						
OUT	0.834	0.847	0.853	0.887	0.921	0.928
0.940						
BURNS	0.684	0.702	0.711	0.759	0.807	0.816
0.834						
NEGLECT	0.895	0.905	0.910	0.937	0.965	0.970
0.980						
REFUSE	0.781	0.796	0.803	0.842	0.881	0.888
0.902						

ARGUE	0.846	0.858	0.865	0.898	0.932	0.938
0.951						
F5 BY						
EDUC	0.036	0.055	0.065	0.116	0.167	0.176
0.195						
TV	-0.130	-0.109	-0.098	-0.040	0.017	0.028
0.050						
NEWS	-0.057	-0.039	-0.030	0.019	0.067	0.076
0.094						
RADIO	-0.086	-0.068	-0.059	-0.012	0.035	0.044
0.062						
PERMIS	-0.065	-0.047	-0.038	0.009	0.057	0.066
0.084						
MONEY	-0.082	-0.066	-0.057	-0.014	0.030	0.038
0.054						
DISTANCE	-0.114	-0.096	-0.086	-0.037	0.011	0.021
0.039						
ALONE	-0.032	-0.011	0.000	0.057	0.114	0.125
0.146						
V511	0.476	0.518	0.539	0.651	0.762	0.784
0.825						
V531R	0.761	0.813	0.840	0.980	1.120	1.146
1.199						
HEALTH	-0.067	-0.050	-0.041	0.005	0.050	0.059
0.076						
PURCHASE	-0.062	-0.049	-0.042	-0.008	0.027	0.033
0.046						
VISIT	-0.041	-0.025	-0.016	0.029	0.075	0.083
0.100						
HUSBAND	-0.125	-0.105	-0.094	-0.039	0.016	0.026
0.047						
HOUSE	-0.043	-0.029	-0.021	0.017	0.055	0.062
0.076						
LAND	-0.050	-0.039	-0.033	-0.003	0.027	0.033
0.044						
OUT	-0.075	-0.058	-0.050	-0.005	0.039	0.047
0.064						
BURNS	-0.070	-0.050	-0.040	0.014	0.068	0.078
0.098						
NEGLECT	-0.098	-0.080	-0.071	-0.024	0.023	0.032
0.050						
REFUSE	-0.063	-0.045	-0.036	0.012	0.061	0.070
0.088						
ARGUE	-0.063	-0.048	-0.040	0.001	0.043	0.051
0.066						
F6 BY						
EDUC	-0.207	-0.182	-0.170	-0.104	-0.038	-0.026
-0.001						
TV	-0.150	-0.123	-0.109	-0.036	0.036	0.050
0.077						
NEWS	-0.074	-0.047	-0.034	0.036	0.107	0.120
0.146						
RADIO	-0.056	-0.027	-0.013	0.064	0.141	0.156
0.185						
PERMIS	-0.070	-0.045	-0.033	0.032	0.098	0.110
0.135						
MONEY	-0.053	-0.030	-0.018	0.045	0.108	0.121
0.144						
DISTANCE	-0.149	-0.124	-0.112	-0.047	0.018	0.031
0.055						
ALONE	-0.081	-0.062	-0.052	-0.001	0.049	0.059
0.078						

V511	-0.093	-0.078	-0.071	-0.030	0.010	0.018
0.033						
V531R	-0.009	0.001	0.007	0.034	0.061	0.067
0.077						
HEALTH	-0.073	-0.056	-0.047	-0.001	0.045	0.054
0.071						
PURCHASE	-0.037	-0.020	-0.011	0.036	0.083	0.092
0.109						
VISIT	-0.182	-0.157	-0.143	-0.075	-0.006	0.007
0.033						
HUSBAND	-0.059	-0.026	-0.009	0.078	0.166	0.183
0.215						
HOUSE	0.638	0.676	0.696	0.798	0.901	0.921
0.959						
LAND	0.843	0.882	0.902	1.005	1.108	1.127
1.166						
OUT	-0.096	-0.077	-0.067	-0.017	0.034	0.044
0.063						
BURNS	-0.146	-0.121	-0.108	-0.042	0.023	0.036
0.061						
NEGLECT	-0.054	-0.032	-0.021	0.037	0.095	0.106
0.128						
REFUSE	-0.067	-0.046	-0.035	0.023	0.080	0.091
0.112						
ARGUE	-0.082	-0.063	-0.053	-0.002	0.050	0.059
0.079						
F1 ON						
WEALTH	0.357	0.377	0.388	0.444	0.500	0.511
0.532						
ETH	-0.553	-0.531	-0.520	-0.462	-0.404	-0.393
-0.371						
TZA	0.305	0.324	0.334	0.385	0.436	0.446
0.465						
F2 ON						
WEALTH	0.189	0.214	0.226	0.292	0.357	0.370
0.394						
ETH	-0.344	-0.318	-0.305	-0.237	-0.168	-0.155
-0.130						
TZA	-0.106	-0.082	-0.070	-0.007	0.057	0.069
0.093						
F3 ON						
WEALTH	-0.001	0.020	0.031	0.086	0.141	0.152
0.173						
ETH	0.265	0.291	0.304	0.372	0.440	0.454
0.479						
TZA	-0.331	-0.310	-0.299	-0.242	-0.185	-0.174
-0.152						
F4 ON						
WEALTH	0.054	0.074	0.084	0.138	0.191	0.201
0.221						
ETH	-0.214	-0.186	-0.172	-0.097	-0.023	-0.008
0.020						
TZA	-0.183	-0.161	-0.150	-0.091	-0.032	-0.020
0.002						
F5 ON						
WEALTH	0.061	0.086	0.098	0.165	0.231	0.244
0.269						
ETH	-0.206	-0.178	-0.163	-0.089	-0.014	0.000
0.028						

TZA	-0.155	-0.133	-0.122	-0.064	-0.005	0.006
0.028						
F6 ON						
WEALTH	-0.441	-0.416	-0.403	-0.338	-0.272	-0.259
-0.235						
ETH	0.043	0.073	0.088	0.165	0.243	0.258
0.287						
TZA	-0.222	-0.195	-0.181	-0.109	-0.036	-0.022
0.005						
HB ON						
F1	-0.065	-0.031	-0.013	0.078	0.170	0.187
0.221						
F2	-0.085	-0.060	-0.047	0.020	0.088	0.101
0.126						
F3	-0.078	-0.053	-0.039	0.029	0.097	0.110
0.136						
F4	-0.067	-0.041	-0.028	0.040	0.108	0.120
0.146						
F5	-0.119	-0.098	-0.087	-0.030	0.026	0.037
0.058						
F6	0.034	0.061	0.075	0.148	0.221	0.235
0.262						
HB ON						
V213	-0.381	-0.362	-0.352	-0.299	-0.246	-0.236
-0.217						
V404	-0.148	-0.126	-0.114	-0.055	0.004	0.016
0.038						
WEALTH	-0.054	-0.028	-0.015	0.053	0.122	0.135
0.161						
ETH	0.071	0.098	0.112	0.184	0.257	0.271
0.298						
TZA	-0.292	-0.267	-0.254	-0.187	-0.120	-0.107
-0.082						
F2 WITH						
F1	-0.026	0.007	0.023	0.110	0.196	0.213
0.245						
F3 WITH						
F1	-0.072	-0.041	-0.026	0.056	0.137	0.152
0.183						
F2	-0.098	-0.060	-0.041	0.061	0.163	0.182
0.220						
F4 WITH						
F1	-0.005	0.021	0.035	0.107	0.179	0.193
0.219						
F2	0.007	0.038	0.054	0.136	0.219	0.234
0.265						
F3	0.036	0.067	0.082	0.162	0.243	0.258
0.288						
F5 WITH						
F1	0.030	0.058	0.072	0.148	0.224	0.238
0.267						
F2	-0.142	-0.114	-0.100	-0.028	0.045	0.059
0.086						
F3	-0.022	0.003	0.016	0.083	0.149	0.162
0.187						
F4	0.004	0.031	0.044	0.115	0.185	0.198
0.225						

F6 WITH						
F1	-0.115	-0.077	-0.058	0.043	0.143	0.163
0.200						
F2	-0.146	-0.110	-0.091	0.007	0.105	0.124
0.161						
F3	-0.043	-0.013	0.003	0.084	0.165	0.181
0.211						
F4	-0.231	-0.200	-0.184	-0.101	-0.019	-0.003
0.028						
F5	-0.136	-0.108	-0.093	-0.016	0.061	0.075
0.104						
Intercepts						
HB	6.203	6.284	6.326	6.543	6.761	6.802
6.884						
EDUC	1.635	1.686	1.711	1.845	1.979	2.004
2.054						
V511	9.968	10.093	10.157	10.490	10.822	10.886
11.011						
V531R	9.922	10.036	10.094	10.397	10.700	10.758
10.871						
Thresholds						
TV$1	0.136	0.185	0.209	0.338	0.467	0.492
0.540						
NEWS$1	0.488	0.532	0.554	0.670	0.786	0.809
0.852						
RADIO$1	-0.515	-0.469	-0.445	-0.322	-0.198	-0.175
-0.128						
PERMIS$1	-1.070	-1.019	-0.993	-0.856	-0.720	-0.693
-0.642						
MONEY$1	-0.445	-0.403	-0.381	-0.269	-0.157	-0.135
-0.093						
DISTANCE	-0.408	-0.366	-0.345	-0.233	-0.121	-0.100
-0.058						
ALONE$1	-0.557	-0.515	-0.494	-0.383	-0.272	-0.251
-0.210						
HEALTH$1	-0.656	-0.610	-0.586	-0.464	-0.341	-0.317
-0.271						
PURCHASE	-0.263	-0.219	-0.196	-0.078	0.040	0.063
0.107						
VISIT$1	-0.544	-0.502	-0.480	-0.367	-0.254	-0.232
-0.189						
HUSBAND$	-0.346	-0.305	-0.283	-0.172	-0.061	-0.040
0.002						
HOUSE$1	0.365	0.409	0.431	0.549	0.667	0.689
0.733						
LAND$1	0.478	0.524	0.547	0.669	0.792	0.815
0.861						
OUT$1	-0.260	-0.214	-0.191	-0.068	0.055	0.079
0.125						
BURNS$1	-0.841	-0.795	-0.771	-0.648	-0.525	-0.501
-0.455						
NEGLECT$	-0.054	-0.006	0.019	0.147	0.275	0.300
0.348						
REFUSE$1	-0.682	-0.636	-0.613	-0.490	-0.367	-0.343
-0.297						
ARGUE$1	-0.209	-0.162	-0.138	-0.012	0.114	0.138
0.185						
Residual Variances						
HB	0.767	0.781	0.789	0.826	0.864	0.871
0.885						

EDUC	0.437	0.458	0.469	0.526	0.582	0.593
0.614						
V511	0.283	0.329	0.352	0.475	0.598	0.622
0.667						
V531R	-0.375	-0.271	-0.218	0.061	0.340	0.394
0.498						
F1	0.459	0.481	0.492	0.552	0.611	0.623
0.645						
F2	0.783	0.800	0.809	0.856	0.903	0.912
0.929						
F3	0.754	0.774	0.784	0.836	0.889	0.899
0.918						
F4	0.921	0.930	0.934	0.957	0.979	0.984
0.992						
F5	0.913	0.923	0.928	0.956	0.983	0.989
0.999						
F6	0.780	0.799	0.809	0.860	0.912	0.922
0.941						

STDY Standardization

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%
Upper .5%						
F1 BY						
EDUC	0.543	0.562	0.572	0.623	0.674	0.683
0.702						
TV	0.528	0.558	0.573	0.651	0.730	0.745
0.775						
NEWS	0.685	0.709	0.721	0.785	0.849	0.861
0.885						
RADIO	0.632	0.657	0.670	0.736	0.802	0.814
0.839						
PERMIS	-0.078	-0.055	-0.043	0.018	0.079	0.091
0.113						
MONEY	-0.048	-0.026	-0.015	0.044	0.104	0.115
0.137						
DISTANCE	-0.082	-0.064	-0.055	-0.006	0.042	0.052
0.070						
ALONE	-0.112	-0.091	-0.080	-0.024	0.033	0.044
0.065						
V511	0.072	0.103	0.118	0.200	0.281	0.297
0.328						
V531R	-0.080	-0.070	-0.065	-0.037	-0.009	-0.004
0.007						
HEALTH	0.001	0.034	0.051	0.138	0.225	0.242
0.275						
PURCHASE	-0.081	-0.070	-0.065	-0.037	-0.008	-0.003
0.008						
VISIT	-0.267	-0.238	-0.224	-0.148	-0.071	-0.057
-0.028						
HUSBAND	0.019	0.044	0.057	0.123	0.190	0.203
0.228						
HOUSE	-0.200	-0.174	-0.160	-0.090	-0.020	-0.007
0.020						
LAND	0.000	0.012	0.018	0.052	0.085	0.092
0.104						
OUT	-0.150	-0.130	-0.120	-0.068	-0.016	-0.006
0.014						
BURNS	0.136	0.166	0.181	0.261	0.341	0.357
0.386						
NEGLECT	-0.113	-0.097	-0.089	-0.046	-0.003	0.005
0.021						

REFUSE	0.012	0.038	0.051	0.121	0.190	0.203
0.229						
ARGUE	-0.070	-0.055	-0.047	-0.007	0.034	0.041
0.056						
F2 BY						
EDUC	-0.059	-0.042	-0.034	0.011	0.056	0.064
0.081						
TV	-0.024	0.011	0.028	0.120	0.212	0.230
0.264						
NEWS	-0.286	-0.244	-0.222	-0.109	0.003	0.025
0.067						
RADIO	-0.058	-0.032	-0.019	0.050	0.118	0.132
0.157						
PERMIS	0.818	0.834	0.842	0.884	0.927	0.935
0.951						
MONEY	0.698	0.716	0.726	0.775	0.824	0.833
0.852						
DISTANCE	0.829	0.845	0.853	0.896	0.938	0.946
0.962						
ALONE	0.744	0.762	0.772	0.821	0.870	0.879
0.898						
V511	-0.081	-0.067	-0.059	-0.021	0.018	0.025
0.039						
V531R	-0.025	-0.016	-0.012	0.012	0.036	0.041
0.050						
HEALTH	-0.092	-0.074	-0.065	-0.018	0.029	0.038
0.055						
PURCHASE	-0.063	-0.047	-0.039	0.004	0.047	0.055
0.072						
VISIT	-0.029	-0.004	0.008	0.074	0.139	0.152
0.176						
HUSBAND	-0.201	-0.165	-0.147	-0.052	0.043	0.061
0.096						
HOUSE	-0.114	-0.093	-0.083	-0.028	0.027	0.037
0.058						
LAND	-0.036	-0.018	-0.009	0.037	0.084	0.093
0.111						
OUT	-0.036	-0.013	-0.001	0.060	0.122	0.134
0.157						
BURNS	-0.103	-0.078	-0.065	0.003	0.072	0.085
0.110						
NEGLECT	-0.132	-0.109	-0.097	-0.036	0.025	0.037
0.060						
REFUSE	-0.119	-0.097	-0.086	-0.028	0.030	0.041
0.062						
ARGUE	-0.069	-0.048	-0.037	0.019	0.075	0.085
0.106						
F3 BY						
EDUC	0.018	0.042	0.054	0.118	0.181	0.193
0.217						
TV	-0.089	-0.067	-0.055	0.004	0.063	0.074
0.096						
NEWS	-0.070	-0.048	-0.037	0.022	0.081	0.092
0.115						
RADIO	-0.208	-0.178	-0.163	-0.082	-0.001	0.015
0.045						
PERMIS	-0.149	-0.127	-0.116	-0.058	0.000	0.012
0.033						
MONEY	-0.096	-0.075	-0.065	-0.011	0.044	0.054
0.074						
DISTANCE	-0.040	-0.021	-0.011	0.041	0.092	0.102
0.121						

ALONE	-0.059	-0.038	-0.028	0.028	0.084	0.094
0.115						
V511	-0.071	-0.057	-0.050	-0.015	0.021	0.028
0.042						
V531R	-0.035	-0.026	-0.021	0.005	0.030	0.035
0.044						
HEALTH	0.807	0.822	0.829	0.868	0.906	0.914
0.928						
PURCHASE	0.902	0.915	0.921	0.953	0.985	0.991
1.004						
VISIT	0.734	0.751	0.760	0.807	0.853	0.862
0.879						
HUSBAND	0.659	0.684	0.697	0.764	0.831	0.844
0.869						
HOUSE	-0.054	-0.033	-0.022	0.034	0.089	0.100
0.121						
LAND	-0.056	-0.044	-0.038	-0.007	0.024	0.030
0.042						
OUT	-0.047	-0.025	-0.014	0.043	0.101	0.112
0.134						
BURNS	-0.110	-0.087	-0.075	-0.013	0.049	0.061
0.084						
NEGLECT	-0.095	-0.075	-0.065	-0.012	0.041	0.052
0.071						
REFUSE	-0.096	-0.075	-0.065	-0.009	0.048	0.058
0.079						
ARGUE	-0.066	-0.049	-0.040	0.008	0.055	0.064
0.081						
F4 BY						
EDUC	-0.045	-0.028	-0.020	0.023	0.067	0.075
0.091						
TV	-0.123	-0.098	-0.085	-0.016	0.052	0.065
0.091						
NEWS	-0.062	-0.040	-0.029	0.031	0.090	0.101
0.123						
RADIO	-0.116	-0.093	-0.081	-0.019	0.042	0.054
0.077						
PERMIS	-0.072	-0.052	-0.042	0.012	0.065	0.075
0.095						
MONEY	-0.057	-0.038	-0.028	0.025	0.077	0.087
0.107						
DISTANCE	-0.123	-0.103	-0.093	-0.041	0.011	0.021
0.041						
ALONE	-0.070	-0.049	-0.037	0.021	0.079	0.090
0.112						
V511	-0.027	-0.014	-0.007	0.028	0.064	0.071
0.084						
V531R	-0.065	-0.056	-0.051	-0.027	-0.003	0.002
0.011						
HEALTH	-0.127	-0.105	-0.094	-0.035	0.023	0.034
0.056						
PURCHASE	-0.065	-0.049	-0.040	0.002	0.045	0.053
0.069						
VISIT	-0.037	-0.014	-0.002	0.060	0.122	0.134
0.157						
HUSBAND	-0.104	-0.084	-0.073	-0.017	0.039	0.049
0.070						
HOUSE	-0.074	-0.057	-0.048	-0.003	0.042	0.051
0.068						
LAND	-0.051	-0.038	-0.031	0.004	0.040	0.047
0.060						
OUT	0.834	0.847	0.853	0.887	0.921	0.928
0.940						

BURNS	0.684	0.702	0.711	0.759	0.807	0.816
0.834						
NEGLECT	0.895	0.905	0.910	0.937	0.965	0.970
0.980						
REFUSE	0.781	0.796	0.803	0.842	0.881	0.888
0.902						
ARGUE	0.846	0.858	0.865	0.898	0.932	0.938
0.951						
F5 BY						
EDUC	0.036	0.055	0.065	0.116	0.167	0.176
0.195						
TV	-0.130	-0.109	-0.098	-0.040	0.017	0.028
0.050						
NEWS	-0.057	-0.039	-0.030	0.019	0.067	0.076
0.094						
RADIO	-0.086	-0.068	-0.059	-0.012	0.035	0.044
0.062						
PERMIS	-0.065	-0.047	-0.038	0.009	0.057	0.066
0.084						
MONEY	-0.082	-0.066	-0.057	-0.014	0.030	0.038
0.054						
DISTANCE	-0.114	-0.096	-0.086	-0.037	0.011	0.021
0.039						
ALONE	-0.032	-0.011	0.000	0.057	0.114	0.125
0.146						
V511	0.476	0.518	0.539	0.651	0.762	0.784
0.825						
V531R	0.761	0.813	0.840	0.980	1.120	1.146
1.199						
HEALTH	-0.067	-0.050	-0.041	0.005	0.050	0.059
0.076						
PURCHASE	-0.062	-0.049	-0.042	-0.008	0.027	0.033
0.046						
VISIT	-0.041	-0.025	-0.016	0.029	0.075	0.083
0.100						
HUSBAND	-0.125	-0.105	-0.094	-0.039	0.016	0.026
0.047						
HOUSE	-0.043	-0.029	-0.021	0.017	0.055	0.062
0.076						
LAND	-0.050	-0.039	-0.033	-0.003	0.027	0.033
0.044						
OUT	-0.075	-0.058	-0.050	-0.005	0.039	0.047
0.064						
BURNS	-0.070	-0.050	-0.040	0.014	0.068	0.078
0.098						
NEGLECT	-0.098	-0.080	-0.071	-0.024	0.023	0.032
0.050						
REFUSE	-0.063	-0.045	-0.036	0.012	0.061	0.070
0.088						
ARGUE	-0.063	-0.048	-0.040	0.001	0.043	0.051
0.066						
F6 BY						
EDUC	-0.207	-0.182	-0.170	-0.104	-0.038	-0.026
-0.001						
TV	-0.150	-0.123	-0.109	-0.036	0.036	0.050
0.077						
NEWS	-0.074	-0.047	-0.034	0.036	0.107	0.120
0.146						
RADIO	-0.056	-0.027	-0.013	0.064	0.141	0.156
0.185						
PERMIS	-0.070	-0.045	-0.033	0.032	0.098	0.110
0.135						

MONEY	-0.053	-0.030	-0.018	0.045	0.108	0.121
0.144						
DISTANCE	-0.149	-0.124	-0.112	-0.047	0.018	0.031
0.055						
ALONE	-0.081	-0.062	-0.052	-0.001	0.049	0.059
0.078						
V511	-0.093	-0.078	-0.071	-0.030	0.010	0.018
0.033						
V531R	-0.009	0.001	0.007	0.034	0.061	0.067
0.077						
HEALTH	-0.073	-0.056	-0.047	-0.001	0.045	0.054
0.071						
PURCHASE	-0.037	-0.020	-0.011	0.036	0.083	0.092
0.109						
VISIT	-0.182	-0.157	-0.143	-0.075	-0.006	0.007
0.033						
HUSBAND	-0.059	-0.026	-0.009	0.078	0.166	0.183
0.215						
HOUSE	0.638	0.676	0.696	0.798	0.901	0.921
0.959						
LAND	0.843	0.882	0.902	1.005	1.108	1.127
1.166						
OUT	-0.096	-0.077	-0.067	-0.017	0.034	0.044
0.063						
BURNS	-0.146	-0.121	-0.108	-0.042	0.023	0.036
0.061						
NEGLECT	-0.054	-0.032	-0.021	0.037	0.095	0.106
0.128						
REFUSE	-0.067	-0.046	-0.035	0.023	0.080	0.091
0.112						
ARGUE	-0.082	-0.063	-0.053	-0.002	0.050	0.059
0.079						
F1 ON						
WEALTH	0.509	0.538	0.553	0.631	0.709	0.724
0.753						
ETH	-0.762	-0.732	-0.717	-0.638	-0.559	-0.544
-0.515						
TZA	0.413	0.438	0.451	0.518	0.586	0.598
0.624						
F2 ON						
WEALTH	0.269	0.304	0.322	0.414	0.507	0.525
0.559						
ETH	-0.475	-0.439	-0.421	-0.327	-0.233	-0.215
-0.180						
TZA	-0.142	-0.110	-0.094	-0.009	0.076	0.093
0.125						
F3 ON						
WEALTH	-0.001	0.029	0.044	0.122	0.201	0.216
0.245						
ETH	0.368	0.403	0.421	0.514	0.607	0.625
0.660						
TZA	-0.445	-0.416	-0.402	-0.325	-0.249	-0.235
-0.206						
F4 ON						
WEALTH	0.078	0.106	0.120	0.196	0.271	0.285
0.313						
ETH	-0.295	-0.257	-0.237	-0.134	-0.031	-0.011
0.027						
TZA	-0.246	-0.216	-0.201	-0.122	-0.043	-0.028
0.002						

F5	ON						
	WEALTH	0.087	0.122	0.140	0.234	0.329	0.347
0.382							
	ETH	-0.284	-0.245	-0.226	-0.123	-0.020	0.000
0.039							
	TZA	-0.208	-0.179	-0.164	-0.086	-0.007	0.008
0.037							
F6	ON						
	WEALTH	-0.625	-0.590	-0.572	-0.480	-0.387	-0.370
-0.335							
	ETH	0.060	0.101	0.121	0.229	0.336	0.356
0.397							
	TZA	-0.299	-0.262	-0.244	-0.146	-0.048	-0.030
0.007							
HB	ON						
	F1	-0.065	-0.031	-0.013	0.078	0.170	0.187
0.221							
	F2	-0.085	-0.060	-0.047	0.020	0.088	0.101
0.126							
	F3	-0.078	-0.053	-0.039	0.029	0.097	0.110
0.136							
	F4	-0.067	-0.041	-0.028	0.040	0.108	0.120
0.146							
	F5	-0.119	-0.098	-0.087	-0.030	0.026	0.037
0.058							
	F6	0.034	0.061	0.075	0.148	0.221	0.235
0.262							
HB	ON						
	V213	-0.938	-0.890	-0.866	-0.738	-0.609	-0.585
-0.537							
	V404	-0.300	-0.255	-0.232	-0.112	0.008	0.031
0.076							
	WEALTH	-0.076	-0.040	-0.021	0.076	0.173	0.192
0.228							
	ETH	0.098	0.135	0.155	0.255	0.355	0.374
0.411							
	TZA	-0.393	-0.359	-0.342	-0.252	-0.162	-0.145
-0.111							
F2	WITH						
	F1	-0.026	0.007	0.023	0.110	0.196	0.213
0.245							
F3	WITH						
	F1	-0.072	-0.041	-0.026	0.056	0.137	0.152
0.183							
	F2	-0.098	-0.060	-0.041	0.061	0.163	0.182
0.220							
F4	WITH						
	F1	-0.005	0.021	0.035	0.107	0.179	0.193
0.219							
	F2	0.007	0.038	0.054	0.136	0.219	0.234
0.265							
	F3	0.036	0.067	0.082	0.162	0.243	0.258
0.288							
F5	WITH						
	F1	0.030	0.058	0.072	0.148	0.224	0.238
0.267							

F2	-0.142	-0.114	-0.100	-0.028	0.045	0.059
0.086						
F3	-0.022	0.003	0.016	0.083	0.149	0.162
0.187						
F4	0.004	0.031	0.044	0.115	0.185	0.198
0.225						
F6 WITH						
F1	-0.115	-0.077	-0.058	0.043	0.143	0.163
0.200						
F2	-0.146	-0.110	-0.091	0.007	0.105	0.124
0.161						
F3	-0.043	-0.013	0.003	0.084	0.165	0.181
0.211						
F4	-0.231	-0.200	-0.184	-0.101	-0.019	-0.003
0.028						
F5	-0.136	-0.108	-0.093	-0.016	0.061	0.075
0.104						
Intercepts						
HB	6.203	6.284	6.326	6.543	6.761	6.802
6.884						
EDUC	1.635	1.686	1.711	1.845	1.979	2.004
2.054						
V511	9.968	10.093	10.157	10.490	10.822	10.886
11.011						
V531R	9.922	10.036	10.094	10.397	10.700	10.758
10.871						
Thresholds						
TV$1	0.136	0.185	0.209	0.338	0.467	0.492
0.540						
NEWS$1	0.488	0.532	0.554	0.670	0.786	0.809
0.852						
RADIO$1	-0.515	-0.469	-0.445	-0.322	-0.198	-0.175
-0.128						
PERMIS$1	-1.070	-1.019	-0.993	-0.856	-0.720	-0.693
-0.642						
MONEY$1	-0.445	-0.403	-0.381	-0.269	-0.157	-0.135
-0.093						
DISTANCE	-0.408	-0.366	-0.345	-0.233	-0.121	-0.100
-0.058						
ALONE$1	-0.557	-0.515	-0.494	-0.383	-0.272	-0.251
-0.210						
HEALTH$1	-0.656	-0.610	-0.586	-0.464	-0.341	-0.317
-0.271						
PURCHASE	-0.263	-0.219	-0.196	-0.078	0.040	0.063
0.107						
VISIT$1	-0.544	-0.502	-0.480	-0.367	-0.254	-0.232
-0.189						
HUSBAND$	-0.346	-0.305	-0.283	-0.172	-0.061	-0.040
0.002						
HOUSE$1	0.365	0.409	0.431	0.549	0.667	0.689
0.733						
LAND$1	0.478	0.524	0.547	0.669	0.792	0.815
0.861						
OUT$1	-0.260	-0.214	-0.191	-0.068	0.055	0.079
0.125						
BURNS$1	-0.841	-0.795	-0.771	-0.648	-0.525	-0.501
-0.455						
NEGLECT$	-0.054	-0.006	0.019	0.147	0.275	0.300
0.348						
REFUSE$1	-0.682	-0.636	-0.613	-0.490	-0.367	-0.343
-0.297						

ARGUE$1	-0.209	-0.162	-0.138	-0.012	0.114	0.138
0.185						
Residual Variances						
HB	0.767	0.781	0.789	0.826	0.864	0.871
0.885						
EDUC	0.437	0.458	0.469	0.526	0.582	0.593
0.614						
V511	0.283	0.329	0.352	0.475	0.598	0.622
0.667						
V531R	-0.375	-0.271	-0.218	0.061	0.340	0.394
0.498						
F1	0.459	0.481	0.492	0.552	0.611	0.623
0.645						
F2	0.783	0.800	0.809	0.856	0.903	0.912
0.929						
F3	0.754	0.774	0.784	0.836	0.889	0.899
0.918						
F4	0.921	0.930	0.934	0.957	0.979	0.984
0.992						
F5	0.913	0.923	0.928	0.956	0.983	0.989
0.999						
F6	0.780	0.799	0.809	0.860	0.912	0.922
0.941						

STD Standardization

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%
Upper .5%						
F1 BY						
EDUC	1.594	1.676	1.719	1.938	2.158	2.200
2.282						
TV	0.575	0.615	0.635	0.742	0.848	0.869
0.909						
NEWS	0.743	0.779	0.798	0.895	0.992	1.010
1.047						
RADIO	0.699	0.735	0.754	0.851	0.949	0.968
1.004						
PERMIS	-0.083	-0.059	-0.046	0.019	0.084	0.097
0.121						
MONEY	-0.051	-0.028	-0.016	0.047	0.109	0.121
0.145						
DISTANCE	-0.087	-0.068	-0.058	-0.006	0.045	0.055
0.074						
ALONE	-0.118	-0.096	-0.084	-0.025	0.034	0.046
0.068						
V511	0.109	0.158	0.183	0.314	0.445	0.470
0.519						
V531R	-0.122	-0.107	-0.099	-0.056	-0.014	-0.006
0.010						
HEALTH	0.002	0.037	0.054	0.145	0.236	0.253
0.288						
PURCHASE	-0.088	-0.077	-0.071	-0.040	-0.009	-0.003
0.008						
VISIT	-0.290	-0.259	-0.243	-0.159	-0.075	-0.059
-0.028						
HUSBAND	0.021	0.047	0.060	0.128	0.197	0.210
0.236						
HOUSE	-0.215	-0.187	-0.173	-0.097	-0.021	-0.007
0.022						
LAND	0.000	0.013	0.020	0.055	0.090	0.097
0.110						

OUT	-0.152	-0.132	-0.122	-0.069	-0.016	-0.006
0.014						
BURNS	0.140	0.172	0.188	0.275	0.361	0.378
0.410						
NEGLECT	-0.115	-0.098	-0.090	-0.047	-0.003	0.005
0.021						
REFUSE	0.012	0.038	0.052	0.123	0.195	0.209
0.235						
ARGUE	-0.071	-0.056	-0.048	-0.007	0.034	0.042
0.057						
F2 BY						
EDUC	-0.184	-0.132	-0.105	0.034	0.173	0.200
0.252						
TV	-0.028	0.012	0.032	0.137	0.242	0.262
0.301						
NEWS	-0.323	-0.275	-0.251	-0.125	0.002	0.026
0.073						
RADIO	-0.066	-0.037	-0.022	0.058	0.137	0.152
0.182						
PERMIS	0.858	0.878	0.889	0.942	0.996	1.007
1.027						
MONEY	0.727	0.747	0.758	0.814	0.870	0.880
0.901						
DISTANCE	0.867	0.887	0.897	0.950	1.003	1.013
1.033						
ALONE	0.773	0.794	0.806	0.864	0.922	0.933
0.955						
V511	-0.127	-0.105	-0.093	-0.033	0.028	0.039
0.062						
V531R	-0.039	-0.025	-0.018	0.019	0.055	0.062
0.076						
HEALTH	-0.096	-0.078	-0.068	-0.019	0.030	0.040
0.058						
PURCHASE	-0.069	-0.051	-0.042	0.005	0.052	0.061
0.078						
VISIT	-0.031	-0.005	0.009	0.079	0.150	0.164
0.190						
HUSBAND	-0.209	-0.172	-0.153	-0.054	0.045	0.064
0.101						
HOUSE	-0.123	-0.101	-0.089	-0.030	0.029	0.040
0.062						
LAND	-0.038	-0.019	-0.010	0.040	0.089	0.099
0.117						
OUT	-0.037	-0.014	-0.002	0.062	0.125	0.137
0.160						
BURNS	-0.109	-0.082	-0.068	0.004	0.075	0.089
0.116						
NEGLECT	-0.134	-0.110	-0.099	-0.037	0.025	0.037
0.061						
REFUSE	-0.121	-0.099	-0.088	-0.029	0.030	0.042
0.064						
ARGUE	-0.070	-0.049	-0.038	0.019	0.076	0.087
0.108						
F3 BY						
EDUC	0.056	0.130	0.168	0.366	0.564	0.602
0.676						
TV	-0.101	-0.076	-0.063	0.004	0.072	0.084
0.110						
NEWS	-0.079	-0.054	-0.041	0.025	0.092	0.105
0.130						
RADIO	-0.241	-0.206	-0.188	-0.095	-0.001	0.017
0.052						

PERMIS	-0.159	-0.136	-0.124	-0.062	0.001	0.012
0.036						
MONEY	-0.101	-0.079	-0.068	-0.011	0.046	0.057
0.078						
DISTANCE	-0.043	-0.022	-0.012	0.043	0.098	0.108
0.128						
ALONE	-0.062	-0.040	-0.029	0.029	0.088	0.099
0.121						
V511	-0.111	-0.090	-0.079	-0.023	0.034	0.044
0.066						
V531R	-0.053	-0.039	-0.032	0.007	0.045	0.053
0.067						
HEALTH	0.834	0.852	0.862	0.911	0.961	0.970
0.989						
PURCHASE	0.963	0.982	0.991	1.042	1.093	1.102
1.121						
VISIT	0.779	0.800	0.812	0.869	0.927	0.938
0.959						
HUSBAND	0.676	0.704	0.719	0.794	0.870	0.885
0.913						
HOUSE	-0.058	-0.035	-0.024	0.036	0.096	0.107
0.130						
LAND	-0.059	-0.047	-0.041	-0.008	0.025	0.032
0.044						
OUT	-0.048	-0.026	-0.015	0.044	0.103	0.114
0.136						
BURNS	-0.116	-0.092	-0.079	-0.014	0.051	0.064
0.088						
NEGLECT	-0.096	-0.076	-0.065	-0.012	0.042	0.052
0.072						
REFUSE	-0.099	-0.077	-0.066	-0.009	0.049	0.060
0.081						
ARGUE	-0.068	-0.050	-0.040	0.008	0.056	0.065
0.083						
F4 BY						
EDUC	-0.139	-0.088	-0.063	0.072	0.207	0.233
0.284						
TV	-0.140	-0.111	-0.096	-0.018	0.060	0.074
0.104						
NEWS	-0.071	-0.046	-0.033	0.035	0.103	0.116
0.141						
RADIO	-0.134	-0.107	-0.093	-0.022	0.049	0.062
0.089						
PERMIS	-0.076	-0.055	-0.044	0.012	0.069	0.080
0.101						
MONEY	-0.060	-0.040	-0.029	0.026	0.081	0.092
0.112						
DISTANCE	-0.130	-0.110	-0.099	-0.044	0.012	0.023
0.043						
ALONE	-0.074	-0.051	-0.039	0.022	0.083	0.095
0.118						
V511	-0.043	-0.022	-0.011	0.045	0.100	0.111
0.132						
V531R	-0.099	-0.085	-0.078	-0.041	-0.005	0.002
0.016						
HEALTH	-0.133	-0.110	-0.098	-0.037	0.024	0.036
0.059						
PURCHASE	-0.071	-0.053	-0.044	0.003	0.049	0.058
0.076						
VISIT	-0.039	-0.015	-0.002	0.065	0.131	0.144
0.169						
HUSBAND	-0.109	-0.087	-0.076	-0.018	0.040	0.051
0.073						

HOUSE	-0.080	-0.061	-0.052	-0.003	0.046	0.055
0.073						
LAND	-0.054	-0.040	-0.033	0.005	0.042	0.049
0.064						
OUT	0.849	0.862	0.869	0.904	0.939	0.945
0.958						
BURNS	0.723	0.741	0.750	0.799	0.848	0.857
0.875						
NEGLECT	0.904	0.915	0.920	0.949	0.978	0.983
0.994						
REFUSE	0.797	0.813	0.820	0.862	0.903	0.911
0.926						
ARGUE	0.861	0.874	0.881	0.915	0.950	0.956
0.969						
F5 BY						
EDUC	0.104	0.165	0.197	0.360	0.523	0.554
0.615						
TV	-0.148	-0.124	-0.111	-0.046	0.020	0.032
0.057						
NEWS	-0.065	-0.044	-0.034	0.021	0.077	0.087
0.108						
RADIO	-0.100	-0.079	-0.069	-0.014	0.041	0.051
0.072						
PERMIS	-0.070	-0.051	-0.041	0.010	0.060	0.070
0.089						
MONEY	-0.086	-0.069	-0.060	-0.015	0.031	0.040
0.057						
DISTANCE	-0.121	-0.101	-0.091	-0.040	0.012	0.022
0.041						
ALONE	-0.034	-0.012	0.000	0.060	0.120	0.132
0.154						
V511	0.747	0.813	0.846	1.022	1.198	1.232
1.298						
V531R	1.134	1.221	1.266	1.498	1.731	1.775
1.862						
HEALTH	-0.071	-0.053	-0.043	0.005	0.053	0.062
0.080						
PURCHASE	-0.068	-0.054	-0.046	-0.009	0.029	0.036
0.051						
VISIT	-0.045	-0.026	-0.017	0.032	0.080	0.090
0.108						
HUSBAND	-0.130	-0.109	-0.098	-0.041	0.016	0.027
0.049						
HOUSE	-0.046	-0.031	-0.023	0.018	0.059	0.067
0.082						
LAND	-0.053	-0.041	-0.035	-0.003	0.028	0.034
0.046						
OUT	-0.076	-0.059	-0.050	-0.006	0.039	0.048
0.065						
BURNS	-0.074	-0.053	-0.042	0.015	0.071	0.082
0.103						
NEGLECT	-0.099	-0.081	-0.072	-0.024	0.023	0.033
0.050						
REFUSE	-0.065	-0.046	-0.037	0.013	0.062	0.072
0.090						
ARGUE	-0.065	-0.049	-0.041	0.001	0.043	0.051
0.067						
F6 BY						
EDUC	-0.644	-0.567	-0.528	-0.323	-0.119	-0.079
-0.003						
TV	-0.171	-0.140	-0.124	-0.041	0.042	0.058
0.089						

NEWS	-0.085	-0.054	-0.039	0.041	0.122	0.137
0.167						
RADIO	-0.064	-0.031	-0.014	0.075	0.163	0.180
0.213						
PERMIS	-0.074	-0.048	-0.035	0.034	0.104	0.117
0.143						
MONEY	-0.056	-0.031	-0.018	0.048	0.114	0.126
0.151						
DISTANCE	-0.158	-0.132	-0.119	-0.050	0.019	0.033
0.059						
ALONE	-0.085	-0.065	-0.055	-0.002	0.052	0.062
0.082						
V511	-0.147	-0.123	-0.111	-0.048	0.016	0.028
0.052						
V531R	-0.014	0.002	0.010	0.052	0.094	0.102
0.118						
HEALTH	-0.077	-0.059	-0.050	-0.001	0.047	0.057
0.075						
PURCHASE	-0.041	-0.022	-0.012	0.039	0.091	0.101
0.120						
VISIT	-0.197	-0.169	-0.155	-0.080	-0.006	0.009
0.037						
HUSBAND	-0.061	-0.027	-0.009	0.081	0.172	0.189
0.223						
HOUSE	0.669	0.714	0.737	0.858	0.979	1.002
1.047						
LAND	0.880	0.924	0.946	1.064	1.182	1.205
1.249						
OUT	-0.098	-0.079	-0.069	-0.017	0.035	0.045
0.064						
BURNS	-0.153	-0.127	-0.114	-0.045	0.025	0.038
0.064						
NEGLECT	-0.055	-0.033	-0.022	0.037	0.096	0.107
0.129						
REFUSE	-0.069	-0.047	-0.036	0.023	0.082	0.093
0.115						
ARGUE	-0.084	-0.064	-0.054	-0.002	0.051	0.061
0.080						
F1 ON						
WEALTH	0.509	0.538	0.553	0.631	0.709	0.724
0.753						
ETH	-0.762	-0.732	-0.717	-0.638	-0.559	-0.544
-0.515						
TZA	0.413	0.438	0.451	0.518	0.586	0.598
0.624						
F2 ON						
WEALTH	0.269	0.304	0.322	0.414	0.507	0.525
0.559						
ETH	-0.475	-0.439	-0.421	-0.327	-0.233	-0.215
-0.180						
TZA	-0.142	-0.110	-0.094	-0.009	0.076	0.093
0.125						
F3 ON						
WEALTH	-0.001	0.029	0.044	0.122	0.201	0.216
0.245						
ETH	0.368	0.403	0.421	0.514	0.607	0.625
0.660						
TZA	-0.445	-0.416	-0.402	-0.325	-0.249	-0.235
-0.206						
F4 ON						

WEALTH	0.078	0.106	0.120	0.196	0.271	0.285
0.313						
ETH	-0.295	-0.257	-0.237	-0.134	-0.031	-0.011
0.027						
TZA	-0.246	-0.216	-0.201	-0.122	-0.043	-0.028
0.002						

F5 ON

WEALTH	0.087	0.122	0.140	0.234	0.329	0.347
0.382						
ETH	-0.284	-0.245	-0.226	-0.123	-0.020	0.000
0.039						
TZA	-0.208	-0.179	-0.164	-0.086	-0.007	0.008
0.037						

F6 ON

WEALTH	-0.625	-0.590	-0.572	-0.480	-0.387	-0.370
-0.335						
ETH	0.060	0.101	0.121	0.229	0.336	0.356
0.397						
TZA	-0.299	-0.262	-0.244	-0.146	-0.048	-0.030
0.007						

HB ON

F1	-0.124	-0.058	-0.025	0.149	0.324	0.357
0.422						
F2	-0.163	-0.114	-0.090	0.039	0.167	0.192
0.240						
F3	-0.149	-0.100	-0.075	0.055	0.185	0.210
0.259						
F4	-0.127	-0.079	-0.054	0.076	0.205	0.230
0.279						
F5	-0.227	-0.186	-0.166	-0.058	0.050	0.071
0.111						
F6	0.065	0.117	0.143	0.282	0.421	0.447
0.499						

HB ON

V213	-1.812	-1.715	-1.665	-1.405	-1.146	-1.096
-0.999						
V404	-0.573	-0.487	-0.443	-0.213	0.017	0.061
0.147						
WEALTH	-0.145	-0.076	-0.040	0.145	0.330	0.365
0.434						
ETH	0.181	0.254	0.291	0.485	0.679	0.717
0.789						
TZA	-0.757	-0.691	-0.657	-0.480	-0.303	-0.269
-0.203						

F2 WITH

F1	-0.026	0.007	0.023	0.110	0.196	0.213
0.245						

F3 WITH

F1	-0.072	-0.041	-0.026	0.056	0.137	0.152
0.183						
F2	-0.098	-0.060	-0.041	0.061	0.163	0.182
0.220						

F4 WITH

F1	-0.005	0.021	0.035	0.107	0.179	0.193
0.219						
F2	0.007	0.038	0.054	0.136	0.219	0.234
0.265						

```
    F3                 0.036       0.067       0.082       0.162       0.243       0.258
   0.288

 F5       WITH
    F1                 0.030       0.058       0.072       0.148       0.224       0.238
   0.267
    F2                -0.142      -0.114      -0.100      -0.028       0.045       0.059
   0.086
    F3                -0.022       0.003       0.016       0.083       0.149       0.162
   0.187
    F4                 0.004       0.031       0.044       0.115       0.185       0.198
   0.225

 F6       WITH
    F1                -0.115      -0.077      -0.058       0.043       0.143       0.163
   0.200
    F2                -0.146      -0.110      -0.091       0.007       0.105       0.124
   0.161
    F3                -0.043      -0.013       0.003       0.084       0.165       0.181
   0.211
    F4                -0.231      -0.200      -0.184      -0.101      -0.019      -0.003
   0.028
    F5                -0.136      -0.108      -0.093      -0.016       0.061       0.075
   0.104

 Intercepts
    HB                12.193      12.259      12.292      12.467      12.643      12.676
  12.742
    EDUC               5.320       5.422       5.473       5.744       6.014       6.066
   6.167
    V511              16.248      16.303      16.332      16.479      16.626      16.655
  16.710
    V531R             15.676      15.730      15.757      15.899      16.041      16.069
  16.122

 Thresholds
    TV$1               0.161       0.214       0.242       0.385       0.529       0.556
   0.610
    NEWS$1             0.552       0.602       0.628       0.764       0.899       0.925
   0.976
    RADIO$1           -0.597      -0.543      -0.516      -0.372      -0.229      -0.202
  -0.148
    PERMIS$1          -1.149      -1.092      -1.064      -0.913      -0.762      -0.733
  -0.676
    MONEY$1           -0.468      -0.424      -0.401      -0.283      -0.164      -0.141
  -0.097
    DISTANCE          -0.435      -0.390      -0.367      -0.247      -0.128      -0.105
  -0.060
    ALONE$1           -0.588      -0.544      -0.521      -0.403      -0.286      -0.263
  -0.219
    HEALTH$1          -0.691      -0.642      -0.617      -0.487      -0.357      -0.332
  -0.283
    PURCHASE          -0.288      -0.239      -0.214      -0.085       0.044       0.069
   0.117
    VISIT$1           -0.587      -0.541      -0.518      -0.395      -0.273      -0.250
  -0.204
    HUSBAND$          -0.360      -0.317      -0.295      -0.179      -0.064      -0.041
   0.002
    HOUSE$1            0.388       0.436       0.461       0.590       0.719       0.743
   0.791
    LAND$1             0.503       0.553       0.578       0.709       0.841       0.866
   0.915
    OUT$1             -0.265      -0.218      -0.194      -0.069       0.056       0.080
   0.127
```

BURNS$1	-0.889	-0.839	-0.814	-0.682	-0.549	-0.524
-0.474						
NEGLECT$	-0.054	-0.005	0.019	0.149	0.278	0.303
0.352						
REFUSE$1	-0.700	-0.653	-0.628	-0.501	-0.374	-0.350
-0.303						
ARGUE$1	-0.213	-0.165	-0.140	-0.012	0.116	0.141
0.189						
Residual Variances						
HB	2.676	2.753	2.793	2.999	3.205	3.245
3.322						
EDUC	4.155	4.379	4.494	5.094	5.694	5.808
6.033						
V511	0.693	0.807	0.866	1.173	1.479	1.538
1.653						
V531R	-0.874	-0.630	-0.506	0.144	0.794	0.918
1.161						
F1	0.459	0.481	0.492	0.552	0.611	0.623
0.645						
F2	0.783	0.800	0.809	0.856	0.903	0.912
0.929						
F3	0.754	0.774	0.784	0.836	0.889	0.899
0.918						
F4	0.921	0.930	0.934	0.957	0.979	0.984
0.992						
F5	0.913	0.923	0.928	0.956	0.983	0.989
0.999						
F6	0.780	0.799	0.809	0.860	0.912	0.922
0.941						

MODEL MODIFICATION INDICES

Minimum M.I. value for printing the modification index 10.000

			M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
ON/BY Statements						
EDUC	ON F5	/				
F5	BY EDUC		999.000	0.000	0.000	0.000
EDUC	ON F6	/				
F6	BY EDUC		999.000	0.000	0.000	0.000
TV	ON F4	/				
F4	BY TV		999.000	0.000	0.000	0.000
TV	ON F5	/				
F5	BY TV		999.000	0.000	0.000	0.000
TV	ON F6	/				
F6	BY TV		999.000	0.000	0.000	0.000
NEWS	ON F4	/				
F4	BY NEWS		999.000	0.000	0.000	0.000
NEWS	ON F5	/				
F5	BY NEWS		999.000	0.000	0.000	0.000
NEWS	ON F6	/				
F6	BY NEWS		999.000	0.000	0.000	0.000
RADIO	ON F5	/				
F5	BY RADIO		999.000	0.000	0.000	0.000
RADIO	ON F6	/				
F6	BY RADIO		999.000	0.000	0.000	0.000
F6	ON F6	/				
F6	BY F6		999.000	0.000	0.000	0.000

ON Statements

F1	ON NEWS	32.169	0.563	0.426	0.485
F1	ON MONEY	10.231	0.267	0.202	0.212
F2	ON NEWS	10.750	0.603	0.546	0.622
F2	ON MONEY	18.742	0.608	0.551	0.579
F2	ON V511	15.895	-0.628	-0.569	-0.894
F2	ON V531R	17.949	8.060	7.303	11.169
F2	ON HUSBAND	10.474	-0.431	-0.390	-0.406
F2	ON BURNS	12.732	-0.488	-0.442	-0.465
F3	ON TV	11.302	0.631	0.594	0.677
F3	ON NEWS	17.397	-0.745	-0.701	-0.799
F4	ON TV	31.136	1.613	1.565	1.783
F4	ON PERMIS	17.150	-1.169	-1.135	-1.209
F4	ON MONEY	14.585	0.955	0.927	0.974
F4	ON V511	12.102	-0.947	-0.919	-1.444
F4	ON BURNS	10.017	-0.782	-0.759	-0.799
F5	ON MONEY	12.261	0.693	0.659	0.692
F5	ON V511	10.919	-0.762	-0.724	-1.138
F5	ON V531R	18.212	11.935	11.348	17.353
F5	ON HUSBAND	10.725	-0.603	-0.573	-0.596
F6	ON TV	11.897	0.809	0.764	0.871
F6	ON NEWS	25.696	1.374	1.299	1.480
F6	ON PERMIS	13.180	-0.826	-0.781	-0.832
F6	ON MONEY	18.638	0.863	0.815	0.857
F6	ON V511	14.328	-0.816	-0.771	-1.212
F6	ON V531R	11.428	8.727	8.250	12.617
F6	ON BURNS	12.740	-0.716	-0.677	-0.712
HB	ON HB	999.000	0.000	0.000	0.000
EDUC	ON NEWS	24.882	0.823	0.823	0.301
NEWS	ON EDUC	24.861	0.161	0.161	0.441
PERMIS	ON MONEY	10.110	0.177	0.177	0.174
PERMIS	ON DISTANCE	10.197	-0.228	-0.228	-0.227
MONEY	ON PERMIS	10.108	0.177	0.177	0.179
DISTANCE	ON PERMIS	10.201	-0.228	-0.228	-0.229
DISTANCE	ON ALONE	10.193	0.190	0.190	0.188
ALONE	ON DISTANCE	10.193	0.190	0.190	0.191
V511	ON V511	999.000	0.000	0.000	0.000
V531R	ON V511	13.980	7.208	7.208	7.405
OUT	ON NEGLECT	12.240	0.142	0.142	0.141
NEGLECT	ON OUT	12.242	0.142	0.142	0.143
F1	ON V404	14.266	-0.242	-0.183	-0.090
F4	ON V404	21.661	-0.304	-0.295	-0.146
TV	ON WEALTH	24.826	0.509	0.509	0.314
TV	ON ETH	24.939	0.510	0.510	0.324
NEWS	ON WEALTH	18.867	-0.405	-0.405	-0.250
PERMIS	ON ETH	16.137	-0.396	-0.396	-0.269
MONEY	ON ETH	12.770	0.315	0.315	0.217
V511	ON V404	26.611	-0.596	-0.596	-0.187
V531R	ON V404	15.006	-0.437	-0.437	-0.141
V531R	ON ETH	16.053	0.670	0.670	0.317
WITH Statements					
TV	WITH F3	11.310	0.631	0.631	0.770
TV	WITH F4	31.058	1.611	1.611	1.964
TV	WITH F6	11.901	0.809	0.809	0.986
NEWS	WITH F1	32.167	0.563	0.563	0.762
NEWS	WITH F2	10.716	0.602	0.602	0.814
NEWS	WITH F3	17.371	-0.745	-0.745	-1.007
NEWS	WITH F6	25.703	1.374	1.374	1.859
NEWS	WITH EDUC	24.894	0.823	0.823	0.493
PERMIS	WITH F4	17.141	-1.169	-1.169	-2.405
PERMIS	WITH F6	13.185	-0.826	-0.826	-1.700
MONEY	WITH F1	10.205	0.267	0.267	0.412

MONEY	WITH	F2	18.756	0.608	0.608	0.941
MONEY	WITH	F4	14.596	0.955	0.955	1.478
MONEY	WITH	F5	12.267	0.693	0.693	1.072
MONEY	WITH	F6	18.622	0.862	0.862	1.334
MONEY	WITH	PERMIS	10.108	0.177	0.177	0.563
DISTANCE	WITH	PERMIS	10.198	-0.228	-0.228	-0.984
ALONE	WITH	DISTANCE	10.194	0.190	0.190	0.669
V511	WITH	F2	15.926	-0.737	-0.737	-0.681
V511	WITH	F4	11.479	-1.082	-1.082	-0.999
V511	WITH	F5	11.468	-0.916	-0.916	-0.845
V511	WITH	F6	13.743	-0.937	-0.937	-0.865
V531R	WITH	F2	17.310	1.138	1.138	3.001
V531R	WITH	F4	16.998	1.931	1.931	5.094
V531R	WITH	F6	18.114	1.580	1.580	4.166
V531R	WITH	V511	13.898	8.429	8.429	20.527
HUSBAND	WITH	F2	10.490	-0.431	-0.431	-0.642
HUSBAND	WITH	F5	10.687	-0.602	-0.602	-0.896
BURNS	WITH	F2	12.793	-0.489	-0.489	-0.886
BURNS	WITH	F6	12.537	-0.710	-0.710	-1.286
NEGLECT	WITH	OUT	12.252	0.142	0.142	0.798

PLOT INFORMATION

The following plots are available:

  Sample proportions, estimated and conditional estimated probabilities
  Item characteristic curves
  Information curves

DIAGRAM INFORMATION

  Use View Diagram under the Diagram menu in the Mplus Editor to view the diagram.
  If running Mplus from the Mplus Diagrammer, the diagram opens automatically.

  Diagram output
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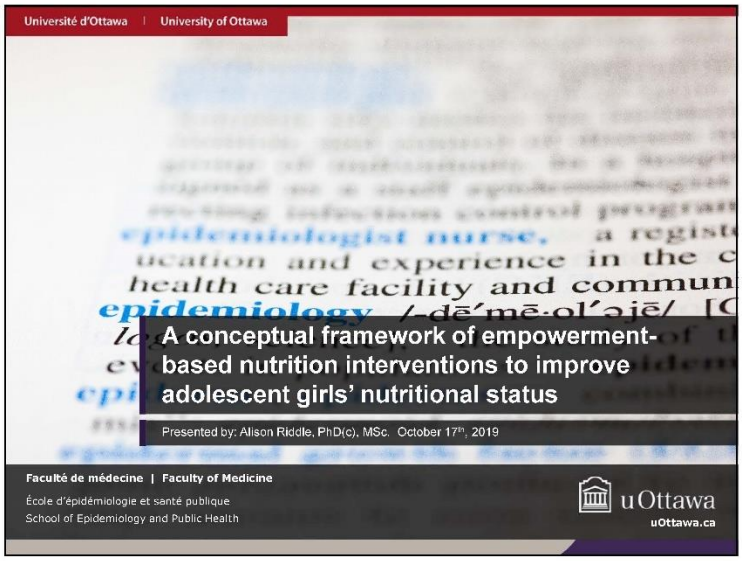
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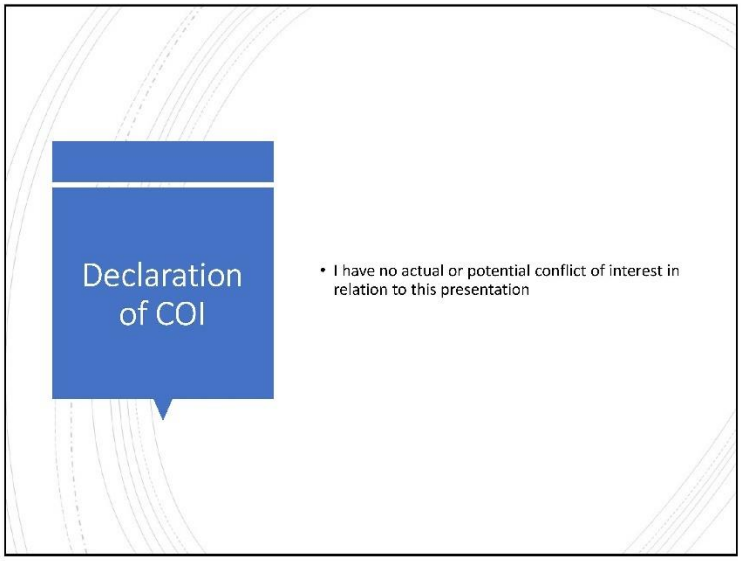
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APPENDIX A5: Conference presentation


Université d'Ottawa | University of Ottawa
A conceptual framework of empowerment-based nutrition interventions to improve adolescent girls' nutritional status
Presented by: Alison Riddle, PhD(c), MSc. October 17th, 2019
Faculté de médecine | Faculty of Medicine
École d'épidémiologie et santé publique
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1


Declaration of COI
• I have no actual or potential conflict of interest in relation to this presentation

2

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3

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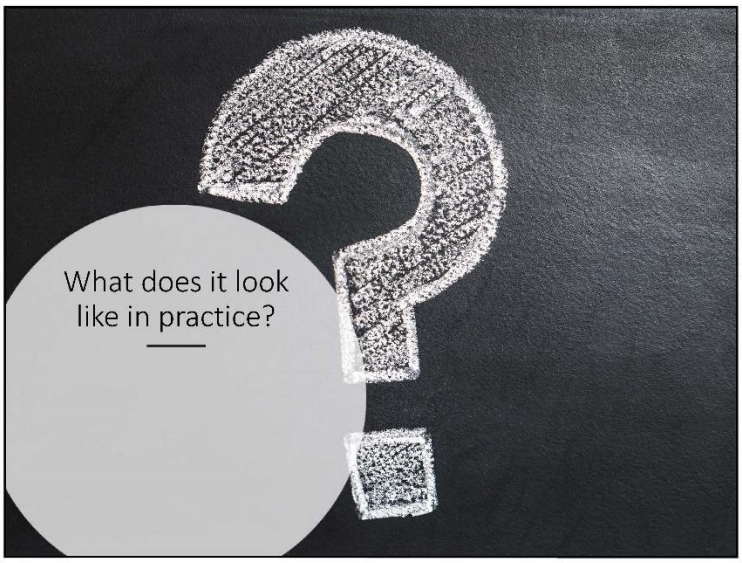
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4


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Background
• Women and girls are more likely to suffer malnutrition compared to men due to their reproductive biology, low social status, and poverty.
• Adolescent girls are especially vulnerable to malnutrition because of their high nutritional needs for growth.
• Early marriage and adolescent pregnancy put adolescent girls at risk of pregnancy complications because they are still growing.
• Empowering women and girls is a global priority to address health and other inequities.

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What does it look like in practice?

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Objective and methods

- Objective
  - To develop and test a theoretical model for the incorporation of empowerment in adolescent girls' nutrition interventions in LMICs
- Methods
  - Literature review of theoretical models of women's empowerment and nutrition
  - Development of a logic model based on Anderson et al. (2011) guidance on using logic models for the systematic review of complex interventions
  - Test the model through the conduct of a mixed-methods systematic review using '*best-fit framework synthesis*'[1]

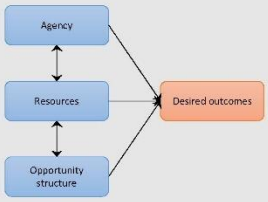
[1] Carroll et al. 2013

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Defining women's empowerment

The ability to make and act on strategic life choices, where such choice was previously denied.



Components :

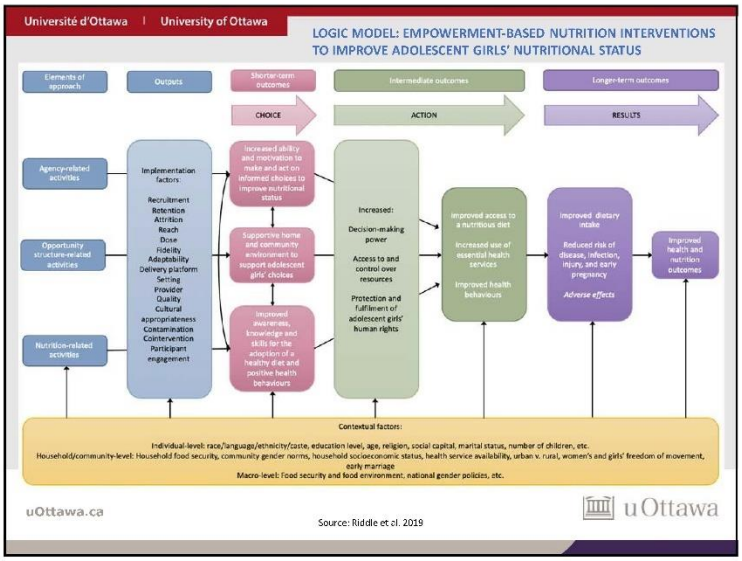
- **Agency**: The motivation and ability to make and act on strategic life choices
- **Resources**: The human, material and physical resources necessary to act on choice
- **Opportunity structure**: The institutional context in which choice is made
- **Desired outcomes**: The achievements that result from choice and action

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Adapted from Kabeer 1999 & 2001, Alsop and Heinsohn 2005

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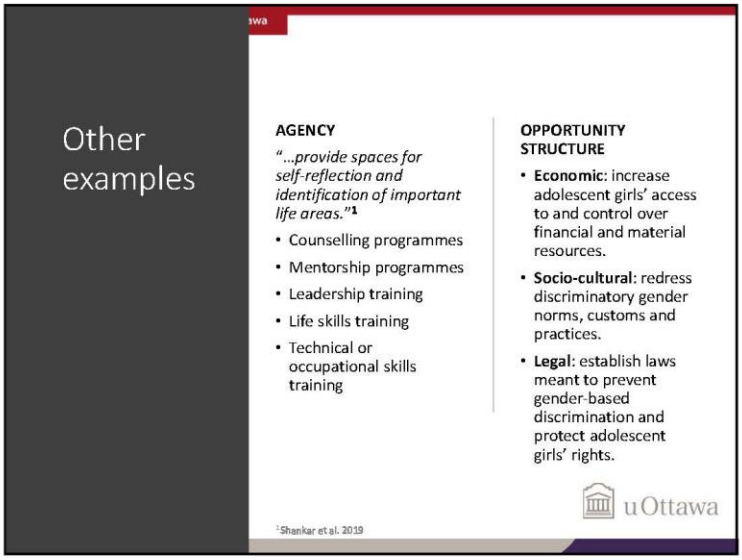
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LOGIC MODEL: EMPOWERMENT-BASED NUTRITION INTERVENTIONS TO IMPROVE ADOLESCENT GIRLS' NUTRITIONAL STATUS
Elements of approach
Outputs
Shorter-term outcomes
Intermediate outcomes
Longer-term outcomes
CHOICE
ACTION
RESULTS
Agency-related activities
Opportunity structure-related activities
Nutrition-related activities
Implementation factors:
Recruitment
Retention
Attrition
Reach
Dose
Fidelity
Adaptability
Delivery platform
Setting
Provider
Quality
Cultural appropriateness
Contamination
Cointervention
Participant engagement
Increased ability and motivation to make and act on informed choices to improve nutritional status
Supportive home and community environment to support adolescent girls' choices
Improved awareness, knowledge and skills for the adoption of a healthy diet and positive health behaviours
Increased:
Decision-making power
Access to and control over resources
Protection and fulfilment of adolescent girls' human rights
Improved access to a nutritious diet
Increased use of essential health services
Improved health behaviours
Improved dietary intake
Reduced risk of disease, infection, injury, and early pregnancy
Adverse effects
Improved health and nutrition outcomes
Contextual factors:
Individual-level: race/language/ethnicity/caste, education level, age, religion, social capital, marital status, number of children, etc.
Household/community-level: Household food security, community gender norms, household socioeconomic status, health service availability, urban v. rural, women's and girls' freedom of movement, early marriage
Macro-level: food security and food environment, national gender policies, etc.
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Source: Riddle et al. 2019
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The Adolescent Girls Empowerment Programme (AGEP) in Zambia
POPULATION COUNCIL
Ideas. Evidence. Impact.
Elements of approach
Nutrition-related activities
Nutrition and SRHR education
Agency-related activities
Weekly girls' group meetings with life skills and financial literacy training
Opportunity structure-related activities
Health voucher and bank account offer
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Source: Hewett et al. 2017
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Other examples
AGENCY
"...provide spaces for self-reflection and identification of important life areas."[1]
• Counselling programmes
• Mentorship programmes
• Leadership training
• Life skills training
• Technical or occupational skills training
OPPORTUNITY STRUCTURE
• Economic: increase adolescent girls' access to and control over financial and material resources.
• Socio-cultural: redress discriminatory gender norms, customs and practices.
• Legal: establish laws meant to prevent gender-based discrimination and protect adolescent girls' rights.
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[1] Shankar et al. 2019

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Search results
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Discussion and conclusion

- Theoretical model to inform the design and evaluation of empowerment-based nutrition interventions for adolescent girls
- Developed to guide a systematic review of adolescent girls' nutrition interventions in LMICs
- Model will be tested and refined in the conduct of the SR over the next year
- The model can assist organizations to design and assess nutrition interventions for adolescent girls that adopt a complete empowerment model



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