

Assessing the determinants of maternal healthcare service utilization and effectiveness of interventions to improve institutional births in Jimma Zone, Ethiopia

Jaameeta Kurji

Thesis submitted to the University of Ottawa
in partial fulfillment of the requirements for a
Doctorate of Philosophy degree in Epidemiology

School of Epidemiology and Public Health

Faculty of Medicine

University of Ottawa

Table of Contents

	List of tables	iv
	List of figures	v
	Abbreviations	vii
	Abstract	viii
	Acknowledgements	ix
	Preface	x
1	Introduction	
1.1	Organization of the thesis	1
1.2	Conceptual framework and objectives	3
1.3	Trends in maternal mortality	8
1.4	Safe motherhood and global commitments	11
1.5	Maternal mortality and access to maternal healthcare	13
1.6	Access to care and service utilization	13
2	Background	
2.1	Overview of the healthcare system in Ethiopia	19
2.2	Definitions of maternal healthcare services	24
2.3	Status of maternal healthcare service use in Ethiopia	26
2.4	Factors influencing maternal healthcare service use	32
2.5	Maternity waiting homes	40
2.6	Role of community and religious leaders in maternal healthcare service use	52
3	Methods	
3.1	Study setting	68
3.2	Evaluation of complex interventions	72
3.3	Sample size calculations for the cluster-randomized control trial	73
3.4	Household survey questionnaire design and data collection	76
3.5	Random selection of eligible women	78
3.6	The MWH ⁺ intervention component	79
3.7	Spatial analytic methods	88
	Trial analyses	97
4	What factors influence whether or not rural Ethiopian women use MWHs?	
4.1	Article preface	106
4.2	Article content	107
5	How does maternal healthcare service use vary within rural Ethiopia?	
5.1	Article preface	126
5.2	Article content	127
6	How do local contextual differences change what influences maternal healthcare service use?	
6.1	Article preface	152
6.2	Article content	153
7	Do MWH⁺ and trained local leaders increase use of maternal healthcare services?	
7.1	Article preface	181
7.2	Article content	182
8	Discussion	
8.1	Having social and financial resources favours MWH use	243
8.2	Context matters: local diversity in factors influencing maternal healthcare service use	246
8.3	Effect of functional MWHs and leader training on delivery care use in rural Ethiopia	248
8.4	Are maternity waiting homes operating in an enabling environment an effective strategy to improve maternal healthcare service use?	252
8.5	Overall limitations and recommendations for future work	260
8.6	Conclusions	262

Table of Contents (continued)

	Chapter 1 Appendix	
A1.1	Overview of the Safe Motherhood project	272
A1.2	Overview of the local leader training intervention component	272
A1.3	Information brief prepared for the National Advisory Committee	273
	Chapter 2 Appendix	
A2.1	Signal functions used to assess EmOC capacity	276
A2.2	Photographs of delivery rooms and postnatal wards at selected study sites	277
A2.3	Quality of evidence on factors associated with ANC use in Ethiopia	278
A2.4	Quality of evidence on factors associated with delivery care use in Ethiopia	279
A2.5	Quality of evidence on factors associated with PNC use in Ethiopia	281
A2.6	Photographs of selected MWHs within the study districts	283
A2.7	Correlations of MWHs with mortality and health outcomes	285
A2.8	Critique on meta-analysis of the effect of MWHs use on perinatal mortality in Africa	287
	Chapter 3 Appendix	
A3.1	Ethical approvals obtained	297
A3.2	Trial protocol paper	304
A3.3	Sources of women's household questions	315
A3.4	Photographs of upgraded MWHs at selected combined intervention sites	316
	Chapter 4 Appendix	
A4.1	Construction of the asset-based wealth index	318
A4.2	MWH use model with distance instead of travel time	321
A4.3	Opinion piece on MWHs during crisis	323
	Chapter 7 Appendix	
A7.1	Ancillary analysis methods	331
A7.2	Ancillary analysis results	335

List of Tables

Table 1.1	Summary of data sources, outcomes of interest and overall analytic approach by thesis-objective	7
Table 3.1	Socio-demographic characteristics of women and men in Oromia compared to urban capital and national averages	71
Table 3.2	Characteristics of study districts in February 2016 prior to baseline survey	71
Table 3.3	Sensitivity analysis of sample size calculations	76
Table 3.4	List of hypothesized requirements essential for a functioning MWH ⁺	83
Table 3.5	Optimal distance bands calculated for each service	91
Table 4.1	Definitions of variables used to explore factors associated with women's use of MWHs	113
Table 4.2	Individual-, household- and community-level characteristics of MWH users compared to non-users	116
Table 4.3	Reasons for MWH stay, and services received among women users	117
Table 4.4	Results from multivariable random effects logistic regression analysis of MWH use among women	118
Table 5.1	Operational definitions of analysis variables used to describe maternal health care service use among women with a pregnancy outcome in 2016-2017	131
Table 5.2	Characteristics of PHCUs and sampled clusters in 2016 within Gomma, Seka Chekorsa and Kersa districts in Jimma Zone, Ethiopia	135
Table 5.3	Primary and main secondary household-level clusters of service use detected using Kulldorf spatial scan statistic	142
Table 6.1	Frequencies, percentages, district- and PHCU-level ranges of explanatory factors	161
Table 6.2	Results from global random effects logistic regression analysis of antenatal, delivery and postnatal care use	163
Table 7.1	Baseline characteristics of clusters and individuals by trial arm	194
Table 7.2	Effectiveness of interventions on improving institutional births and secondary outcomes (ANC, PNC)	195

List of Figures

Chapter One

Figure 1.1	Relationship between thesis foundational themes, research questions and research objectives	4
Figure 1.2	Overall conceptual model for thesis	5
Figure 1.3	Maternal mortality ratios (per 100,000 live births) of the world, Sub-Saharan Africa, East Africa and Ethiopia between 2000 and 2017	8
Figure 1.4	Predicted maternal mortality ratios per 100,000 live births by region in Ethiopia	9

Chapter Two

Figure 2.1	Structure of the health system in rural Ethiopia	22
Figure 2.2	Levels of maternal healthcare service use between 2000 and 2019 in Oromia region	27
Figure 2.3	Regional variation in ANC use	28
Figure 2.4	Regional variation in delivery care use	29
Figure 2.5	Regional variation in PNC use in Ethiopia	29
Figure 2.6	Differences in ANC use between 2000 and 2019 by: (a) place of residence (rural vs. urban), (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs least poor quintiles) in Ethiopia	30
Figure 2.7	Differences in delivery care use between 2000 and 2019 by: (a) place of residence (rural vs. urban) (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs least poor quintiles) in Ethiopia	31
Figure 2.8	Differences in PNC use between 2000 and 2019 by: (a) place of residence (rural vs. urban), (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs least poor quintiles) in Ethiopia	31

Chapter Three

Figure 3.1	Study area map showing the location of: (a) Ethiopia (b) Jimma Zone in Oromia Region (c) study districts in Jimma Zone and (d) PHCUs in study districts.	69
Figure 3.2	Fundamental elements of our trial design	73
Figure 3.3	Flow chart of sample size calculations using Hooper & Bourke methodology	75
Figure 3.4	Framework of the essential elements of the MWH based on the World Health Organization health system building blocks	82
Figure 3.5	Roles and responsibilities of community and health system stakeholders in MWH implementation, outlined in the 2015 Ethiopian national MWH guidelines	86

List of Figures (continued)

Chapter Five

Figure 5.1	Map of the study area showing primary health care unit (PHCU) catchment area boundaries, enrolled households and locations of health centres within PHCUs	130
Figure 5.2	Percentages of surveyed households within 2 km, between 2-5 km and more than 5 km from health centre by PHCU and district in Jimma Zone, Ethiopia	136
Figure 5.3	Choropleth maps highlighting correlation between household wealth and (a) ANC use (b) MWH use (c) Delivery care and (d) PNC use at PHCU-level	137
Figure 5.4	Choropleth maps highlighting correlation between women's education and (a) ANC use (b) MWH use (c) Delivery care and (d) PNC use at PHCU-level	139
Figure 5.5	Hot and cold spots at kebele-level of (a) ANC (b) Delivery care use (c) PNC use in study districts in study districts	140
Figure 5.6	Clusters within kebeles of (a) ANC use (b) MWH use (c) Delivery care use (d) PNC use in study districts	141

Chapter Six

Figure 6.1	Map of the study area showing locations of health centres in PHCUs, main towns, roads, PHCU and district boundaries	157
Figure 6.2	Maps of local association estimates (odds ratios) between ANC use and (a) information source (b) danger sign awareness (c) prior ANC use (d) wealth (e) decision making (f) planned pregnancy (g) parity (h) birth preparedness and (i) health facility type	166
Figure 6.3	Maps of local association estimates (odds ratios) between delivery care and (a) school attendance (b) information source (c) danger sign awareness (d) ANC use (e) prior delivery care use (f) attitude towards delivery care (g) companion support (h) wealth (i) parity (j) birth preparedness (k) health facility type	168
Figure 6.4	Maps of local association estimates (odds ratios) between PNC use and (a) danger sign awareness (b) delivery care use (c) assisted delivery mode (d) companion support	170

Chapter Seven

Figure 7.1	Map of study districts depicting locations of health centres and Jimma Town	186
Figure 7.2	Timeline cluster diagram illustrating participant recruitment, randomization, outcome assessments and blinding status of the trial	190
Figure 7.3	CONSORT participant flow diagram	193
Figure 7.4	Bar charts of (a) dimensions of MWH awareness among women (b) reasons for no institutional delivery	196
Figure 7.5	Bar chart of MWH use and institutional births across PHCUs and over survey periods.	198

Commonly Used Abbreviations

AICc	Corrected Akaike Information Criterion
ANC	Antenatal care
CI	Confidence interval
DHS	Demographic and Health Survey
EmOC	Emergency obstetric care
GWR	Geographically weighted regression
HEW	Health extension worker
ICC	Intra-cluster correlation coefficient
KM	Kilometres
LMICs	Low-and middle-income countries
MDG	Millennium Development Goal
MMR	Maternal mortality ratio
MWH	Maternity waiting homes
OR	Odds ratio
PHCU	Primary health care unit
PNC	Postnatal care
SDG	Sustainable Development Goal
UN	United Nations
WDA	Women's Development Army
WHO	World Health Organization

Abstract

The strong emphasis placed on improving equality and well-being for all in the Sustainable Development Goals underscores the importance of tackling persistent within-country disparities in maternal mortality and poor health outcomes. Addressing maternal healthcare access barriers is, thus, crucial, particularly in low-resource settings. Numerous studies investigating determinants of maternal healthcare service use in Ethiopia exist but are limited by their focus on individual and household factors, and by methodological weaknesses. A nuanced understanding of the role of socioeconomic and geographic context in influencing access to care is needed to respond effectively.

Maternity waiting homes (MWHs) are a potential strategy to address geographical barriers that delay women's access to obstetric care. However, in addition to concerns about service quality, there is limited evidence on their effectiveness and on what models meet women's needs. My research goals were, therefore, to contribute to the understanding of what contextual factors influence maternal healthcare service use in general; and to determine whether or not upgraded MWHs operating in an enabling environment could improve delivery care use in rural Ethiopia. My primary data sources were household surveys conducted as part of a cluster-randomized controlled trial evaluating MWHs and local leader training in Jimma Zone, Ethiopia.

Random effects multivariable logistic regression analysis of survey data brought to light the social and financial resources that facilitate MWH use, highlighting the need for complementary interventions to make access more equitable. Spatial analyses identified subnational variation in service use at a finer scale than routinely reported and unmasked local variation in the relevance and magnitude of associations between individual-, interpersonal-, and health system factors and maternal healthcare use. These findings have implications for relying upon homogenous national responses to improve equality in access to care and health outcomes. Finally, analysis of trial data found a non-significant effect of interventions on delivery care use likely due to implementation issues and extraneous factors. The need to generate strong evidence of effectiveness of MWHs in improving maternal healthcare service use using sustainable and equitable MWH models using methods appropriate for complex intervention evaluation remains.

Acknowledgments

I will begin by thanking my supervisors Dr. Manisha Kulkarni and Dr. Ronald Labonté for giving me the opportunity to meet one of my life goals. A special thank you to Dr. Kulkarni for letting me lead the trial analysis. I express my gratitude to my thesis advisory committee members Dr. Monica Taljaard, Dr. Gail Webber and Dr. Vivian Welch, who together with my supervisors, have expertly guided me along my learning journey. I am grateful to the University of Ottawa for the Excellence Scholarship and to my dissertation examiners (Drs. Sanni Yaya, Deshayne Fell, Daniel Corsi and Nazeem Muhajarine) for their thoughtful comments. I salute everyone on the IMCHA Safe Motherhood Project for being excellent colleagues.

During the last 14 years I have had the privilege of crossing paths with many formidable women passionately dedicated to public health who have played a role in shaping me into the Epidemiologist that I am. Today I thank them: Nasreen Dhanani, Kayli Wild, Zohra Lassi, Ellah Kedera, Lara Vaz, Yasmin Amarsi, Zeenatkhanu Kanji, Mahnaz Motevalli-Oliner, Rachel Nyamai, Phelgona Otieno, Wangui Muthigani, Nitika Pant-Pai, Ritu Barick, Carol Levin, Cornelia Loechl, Khadija Abdalla, Jan Low, Shaheen Sayed, Anayda Portela, Tienke Vermeiden, Daphne McRae, Nelly Mugo, Leah Kirumbi, Philippa Musoke, Monica Etima, Marianna Newkirk, Indra Gupta, Muluemebet Wordofa, Yisalemush Asefa, Nandita Perumal, Lonnie Embleton, Alanna Mihic and Kristy Hackett. I'd also like to recognize all the other individuals I've had the opportunity to work with and learn from including Drs. Zahir Moloo, John Tole, Hermann Ouedraogo, Ziqi Li and many others.

I have been very lucky to have been trained by incredibly accomplished Epidemiologists/Biostatisticians whose enthusiasm for their work stimulated my interest and are the gold standards of what I aspire to be: thank you Drs. Monica Taljaard, Lisa M. Butler, Madhukar Pai and Franco Momoli. Drs. Donald Cole and Rachel King are embodiments of true mentors and I'd like to thank them for continuing to invest in my professional development and for being truly generous with their time and knowledge.

I would also like to acknowledge Anjarwalla & Khanna (Kenya) for their generosity, compassion and commitment to justice during a grim time in our lives. In particular, without the support of Aisha, Tabitha and Abbas I would not have found the strength and hope needed to continue my PhD.

Finally, and most importantly, I thank my four pillars for inspiring and sustaining me. To my father for his undefeatable faith in humanity, his ethic of generosity and concern for the well-being of others that is grounded in his faith and that has motivated my career choices. To my mother for her passion for teaching and learning that gave me the drive to start this PhD and, for her role as my editor, statistical consultant, librarian and cheerleader that ensured I completed it. To my brother, for setting the bar of excellence very, very high but for making me believe that I inspire his extraordinary work ethic and determination. To my husband, for being by my side every step of the way. I dedicate this work to the four of you.

Preface

My earliest memory is of the birth of my brother in a small rural town along the shores of Lake Victoria in Kenya. I remember being scooped up the middle of the night and being placed in a room with an eerie green nightlight. I had no idea what had happened and was, therefore, surprised the next day to find a tiny basket with an even tinier, wrinkled-up object inside it. A few decades later while discussing an antenatal care project with my mother, I learned more about my brother's arrival. My parents had planned to travel to the provincial hospital (a three-hour drive away on dirt roads) as it offered comprehensive obstetric care. However, labour began several weeks early and late at night; my brother was born in the unhygienic, dimly lit, minimally-equipped, local clinic in the company of dead rodents. Throughout my PhD this has been at the back of my mind – despite both having tertiary education, access to financial resources and social support and an intention to use hospital delivery services, my parents had to contend with limited obstetric care because they lived in a rural town separated from health services by poor roads. Context matters and influences more powerful than individual resources and intentions actually shape outcomes.

It was during field visits to Jimma, at a stage in my life when birth was more relevant, that I began to relate to my research more personally. The joy of a newborn can easily be marred by the constraints of circumstances - poverty, enormous distances, lack of choice and voice, isolation from family, fear of mistreatment and death at health facilities. I embarked upon this research in the hopes that maternity waiting homes embedded in supportive environments could transform the experience of birth for rural women. I envisioned social networks rallying round to get couples to health centres where they would be comfortably accommodated alongside their peers under the care of attentive midwives. I imagined co-designing maternity waiting home improvements with community stakeholders and creating opportunities for income generation and enhancing local ownership. I envisaged the leader workshops as platforms for increased dialogue, exchanging ideas and as occasions for boosting cooperation between the community and health workers towards better quality care.

Five years later I still believe this is achievable but I question fragmented and sporadic research efforts constrained within short durations. Strengthening health systems through long-term, public-private partnerships targeting all levels of care using strategies that are genuinely community-centred and appropriately resourced and managed is likely to be more effective at creating resilient, equitable systems. More emphasis on continuously sharing best practices and nurturing creative collaborations is also needed to make evidence more widely accessible. I am humbled by how much more I need to learn but energized by the prospect of it. I will endeavour to meet this challenge with “honest realism and hopeful optimism” (Aga Khan IV, Maternal, Newborn and Child Health Summit Toronto, Canada, 2014)

Chapter 1: Introduction

In 2014, the International Development Research Centre, Canadian Institutes of Health Research and Global Affairs Canada established the IMCHA Initiative (Innovating for Maternal and Child Health in Africa) to “improve maternal, newborn and child health outcomes by strengthening health systems....”.⁽¹⁾ Implementation research teams across Africa partnered with Canadian researchers to formulate solutions to improve access to maternal, newborn and child healthcare and to explore methods to scale up these interventions.

My research was nested within a larger implementation study funded by the IMCHA initiative and often referred to by the team as “The Safe Motherhood Project”. The Safe Motherhood project was led by my co-supervisors Drs. Manisha Kulkarni and Ronald Labonté together with investigators from Jimma University (Mr. Lakew Abebe Gebretsadik, Dr. Sudhakar Morankar and Dr. Muluemebet Abera Wordofa) and the Jimma Zone Health Office (Mr. Kunuz Haji Bedru and Mr. Gebeyehu Bulcha) in Ethiopia.

The main goal of The Safe Motherhood Project was to evaluate interventions that address geographic and social barriers to safe motherhood using both quantitative and qualitative data.⁽²⁾ Two interventions were developed and evaluated: upgraded maternity waiting homes (MWHs⁺)¹ and local leader training. Further details related to the project can be found in Appendix 1.1 to 1.3. I was one of six PhD students, two from University of Ottawa and four from Jimma University, who undertook their doctoral research on different aspects of the project. My role in the project included contributing to intervention design, formulation of data collection tools, sample size calculations and, analysing the main trial outcomes. These contributions are outlined in more detail in later sections.

1.1. Organization of thesis

The thesis is organized into eight chapters as follows:

(Chapter 1) Introduction: I begin this chapter by outlining key features of the Safe Motherhood Project, stating my research objectives and elaborating on the conceptual model that I used to guide my work. I then describe the extent of the public health problem by examining the status of maternal health and mortality in Sub-Saharan Africa in general and, in Ethiopia specifically. I also briefly discuss global commitments to make motherhood safer as they form the broader context within which my work is situated. Finally, I touch upon access to maternal healthcare services as a determinant of maternal health.

¹ The + is used to distinguish between upgraded MWHs that are one of the intervention components under evaluation and MWHs that exist as part of usual care

(Chapter 2) Background: In this chapter, I talk about the development and structure of the healthcare system in Ethiopia and provide definitions of the specific maternal healthcare services I am investigating. I follow this with an examination of the status of antenatal care (ANC), delivery care and postnatal care (PNC) use in Ethiopia. I also summarize available evidence on factors associated with the ANC, MWH, delivery care and PNC use and discuss gaps that exist as part of the rationale for my research. I end this chapter with a summary of the role of community and religious leaders in maternal healthcare services, as these leaders are the target of the second intervention component that I evaluate as part of the main trial outcomes analysis.

(Chapter 3) Methods: While design and analysis details are integrated within each article, in this chapter I describe the study setting in more detail to provide context to the findings. I also describe the development of the household surveys, to which I contributed, as these comprise the main data sources for my work. I also outline the sample size calculations and random selection process for trial participants, describe how the MWH intervention component was developed and provide an overview of spatial and trial-related analyses.

(Chapter 4 -7) Articles: I present each manuscript as a separate chapter prefaced with a brief note on the how the article relates to other work in the thesis. As required by the University of Ottawa, co-author contributions to the paper, ethical approvals received and a list of any associated appendices has been included. Citation details are provided for published articles.

In the first article published in *BMJ Open*, I investigate what factors are associated with the use of MWHs prior to introducing interventions in the study area to understand why women may or may not use this maternal healthcare service. In chapter five, I begin to explore how locality plays a role in utilization by examining how use of MWHs as well as ANC, delivery care and PNC services vary at sub-national levels. In this article, published in *BMC Health Services Research*, I reflect on the implications of unequal service access on achieving equitable care coverage. I build on this work by using geographically-weighted regressions to investigate spatial variability in associations between service use and candidate explanatory factors in a second article published in *BMC Health Services Research* presented in chapter six.

Finally, in chapter seven I include the article published in *BMC Global Health* where I evaluate the effectiveness of MWHs⁺ and local leader training in improving the use of delivery care services using trial data.

(Chapter 8) Discussion: In my final chapter, I recap the main findings and discuss how together they contribute to existing evidence around maternal healthcare service use and MWH effectiveness in Ethiopia. I compare my findings to those from other studies to situate them in the global context and reflect on implications for Ethiopia and similar settings. I also describe limitations associated with my work and propose areas that require further research.

1.2. Conceptual framework and objectives

1.2.1. Thesis objectives

The overall goal of my thesis was to develop a nuanced understanding of the relationships between use of maternal healthcare services and factors that influence it; and then to evaluate interventions that address contextual (geographical and social) barriers to improve women's access to maternal healthcare services.

As shown in Figure 1.1, this thesis aims to contribute to research efforts directed at reducing maternal mortality in low-resource settings, which concentrate on understanding challenges in accessing maternal healthcare services and testing interventions to address these barriers. Access to maternal healthcare is viewed as one determinant of maternal health and is investigated in this thesis using service use as a proxy measure. The reason for a focus on geographic and social aspects of service utilization is two-fold: firstly, to improve equity in maternal health outcomes, identifying areas with either low levels of service use or population groups exhibiting low levels of use along a social gradient is necessary to target interventions appropriately; and secondly, women's ability to access services is shaped not only by their own individual-level characteristics, but also by contextual factors that operate at levels of the households and communities in which they live, and the health system where maternal healthcare services are located.

The specific objectives of my thesis are:

Objective 1: To identify factors associated with MWH use in a rural, low-resource setting using baseline household survey data collected in three districts in Jimma Zone, Ethiopia;

Objective 2a: To explore spatial variation in maternal healthcare service use at sub-national level using baseline household survey data collected in three districts in Jimma Zone, Ethiopia;

Objective 2b: To characterize spatial variation in relationships between factors associated with maternal healthcare service use using baseline household survey data collected in three districts in Jimma Zone, Ethiopia;

Objective 3: To assess the effectiveness of MWHs⁺ and leader training in improving use of delivery care services in three districts in Jimma Zone, Ethiopia.

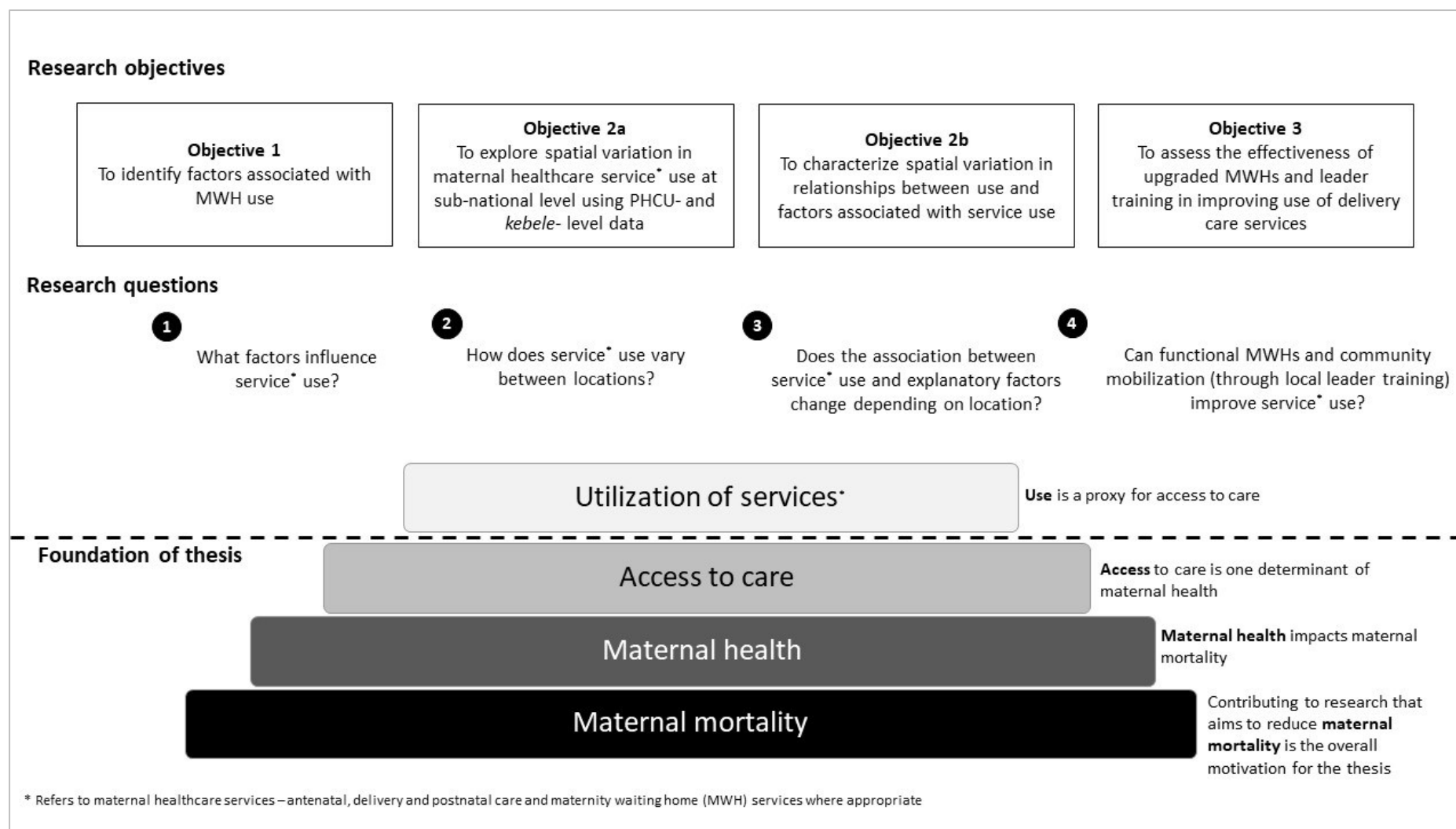


Figure 1.1. Relationship between thesis foundational themes, research questions and research objectives

1.2.2. Conceptual model

In order to delineate the scope of the thesis, relate the various research components to one another and guide selection of variables for analysis, I created a conceptual model shown in Figure 1.2. In this model, individual woman characteristics together with multilevel factors from the context in which she lives act to create delays in women seeking care and reaching facilities that provide maternal healthcare services. Health system factors such as quality of care create delays in women receiving care once they are there.

I used a social ecological perspective to guide selection of variables from the literature² at the community, household/inter-personal, health system and individual woman levels to model associations between these factors and service use. Social ecological approaches explicitly recognize the role that contextual factors, such as physical environments, social norms, policies, etc., play in creating opportunities, shaping behaviours and influencing health outcomes.(3)

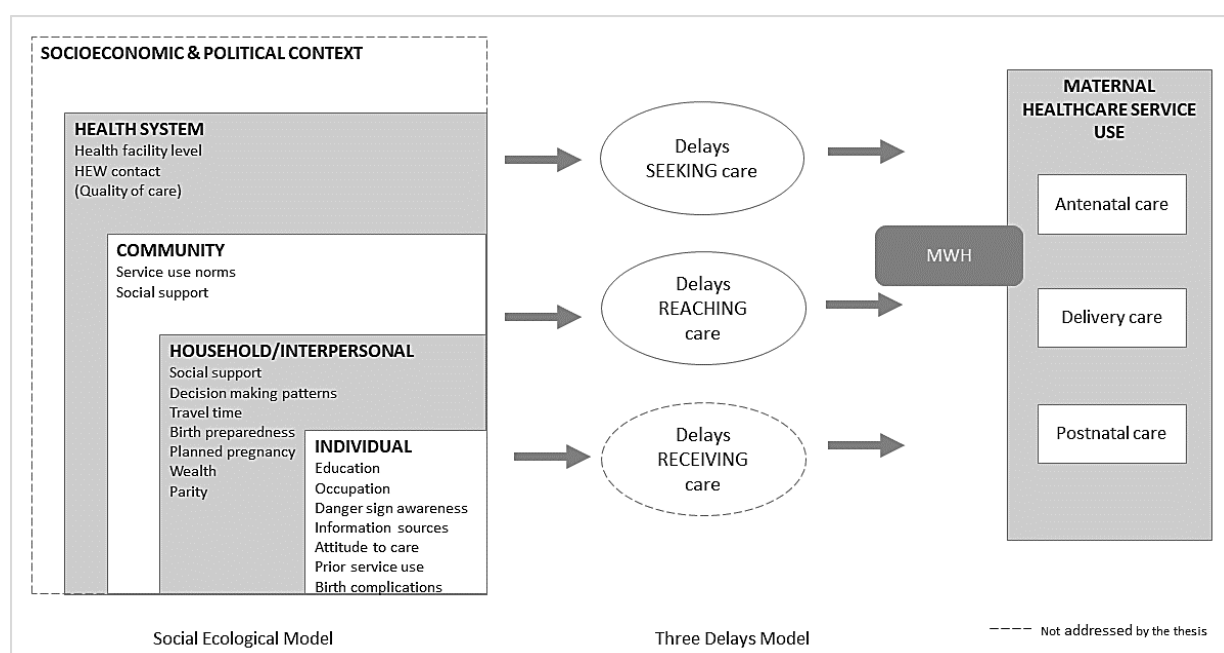


Figure 1.2. Overall conceptual model for thesis

Models using this approach typically include “multiple levels of influence. (4) For instance, the model described by McLeroy et al. includes intrapersonal, interpersonal, institutional, community and public policy levels.(5) The World Health Organization (WHO) also adopted a social ecological perspective for their framework of social determinants of health.(6,7) Social determinants of health are the daily living conditions and broader structural factors, such as social and economic policies and

² A review of literature on factors correlated with service use is provided in Chapter 2

political climates, that result in differential access to opportunities and resources between people. These differences are viewed as unfair because they are avoidable and further marginalize already disenfranchised groups such as the poor.(8)

While the data used in this thesis preclude an exploration of macro-level contextual factors such as political contexts, I included this level in the conceptual framework as a reminder that women, households and communities are embedded within broader regional, national and global contexts which exert influences on individuals and the opportunities available to them. In fact, the policy context relevant to my research is one where delivery care use is heavily promoted and MWHs are being scaled up across Ethiopia.(9) Although intended to reduce preventable maternal morbidity and mortality, the policy emphasis on facility-based delivery care has also been described as resulting in unintended pressure on women, imposing restrictions on their freedom to choose and their subjection to social sanctions.(10)

The second theoretical model I integrated into my conceptual framework draws from work by Thaddeus and Maine on types of delays that women with obstetric complications experience, which may ultimately result in maternal death.(11) In this framework, delays in accessing obstetric care occur when deciding to seek care, in trying to reach care facilities and then in receiving care once women have arrived. In my thesis conceptual model, the “Three Delays model” serves as a mechanism to explain how multilevel factors could affect maternal healthcare service utilization levels. For instance, women may experience delays in deciding to use delivery care (first delay) when they have low danger sign awareness (individual factor), live in less wealthy households (interpersonal/household factor) that are located in *kebeles* where most women give birth at home (community factor). The large distances between homes and health facilities, especially when villages do not have easy access to road networks and where transport costs are prohibitively high, may cause delays in reaching health facilities for delivery even when women wish to do so (second delay). While quality of care is also likely to affect service use and the third delay, it was not feasible to collect data about this factor

1.2.3. Linking the conceptual model to thesis objectives

The first objective of my thesis was to understand what individual and contextual factors influenced the use of MWH services. I considered MWHs separately from other maternal healthcare services as they were the target for one of the main trial interventions being developed and evaluated. Additionally, MWHs differ from other services in that they are constructed and operated in partnership with the community, and may have slight differences in factors that affect their use.

The second thesis objective was split into two parts: first, using descriptive spatial statistics, I explored patterns in use of ANC, MWH, delivery care and PNC at several geographic levels to identify areas and population groups that were lagging behind in the pre-intervention phase. Following this, I

identified factors associated with services other than MWHs, tested for the presence of spatial autocorrelation and, then ascertained the role that location plays in determining what correlates with service use using geographically weighted regression models.

The final objective was to assess the effectiveness of interventions in improving delivery care use by assessing changes in levels of institutional births. The leader training intervention was hypothesized to influence factors at the community, household and individual level such as social support for service use, women's involvement in decision making, and danger sign awareness. This was expected to contribute towards reducing first and second delays and, thereby, improve women's use of delivery care services. The MWH⁺ intervention component was hypothesized to act by encouraging delivery care service use through improved quality and better awareness thereby reducing second and third delays.

A summary of the relationship between objectives, data sources, outcomes of interest and the analytic approach used for each research objective is outlined in Table 1.1.

Table 1.1. Summary of data sources, outcomes of interest and overall analytic approach by thesis-objective

Objective	Survey data source	Service(s) of interest	Overall analytic approach
Objective 1	Baseline	MWH	Random effects logistic regression using clustered data to identify factors associated with MWH use
Objective 2a	Baseline	ANC Delivery care PNC	Visualize spatial distribution using choropleth maps, investigate presence of global spatial autocorrelation and detect locations of clusters of high and low service use using local spatial statistics such as Moran's I and Getis Ord Gi*
Objective 2b	Baseline	ANC Delivery care PNC	Random effects logistic regression to identify factors associated with use of each service followed by Moran's I tests on residuals to investigate presence of spatial autocorrelation. Assess local variation in relationships between service use and candidate explanatory variables using geographically-weighted regressions
Objective 3	Baseline and endline	Delivery care	Random effects logistic regression to compare changes at endline in levels of institutional births (main trial outcome) between intervention and control arms.

1.3. Trends in maternal mortality

The WHO defines maternal deaths as deaths among women while they are pregnant or within 42 days of pregnancy termination from any cause related to or exacerbated by the pregnancy or its management.(12) The maternal mortality ratio (MMR) is computed as the number of maternal deaths per 100,000 live births and used to monitor maternal mortality.(12)

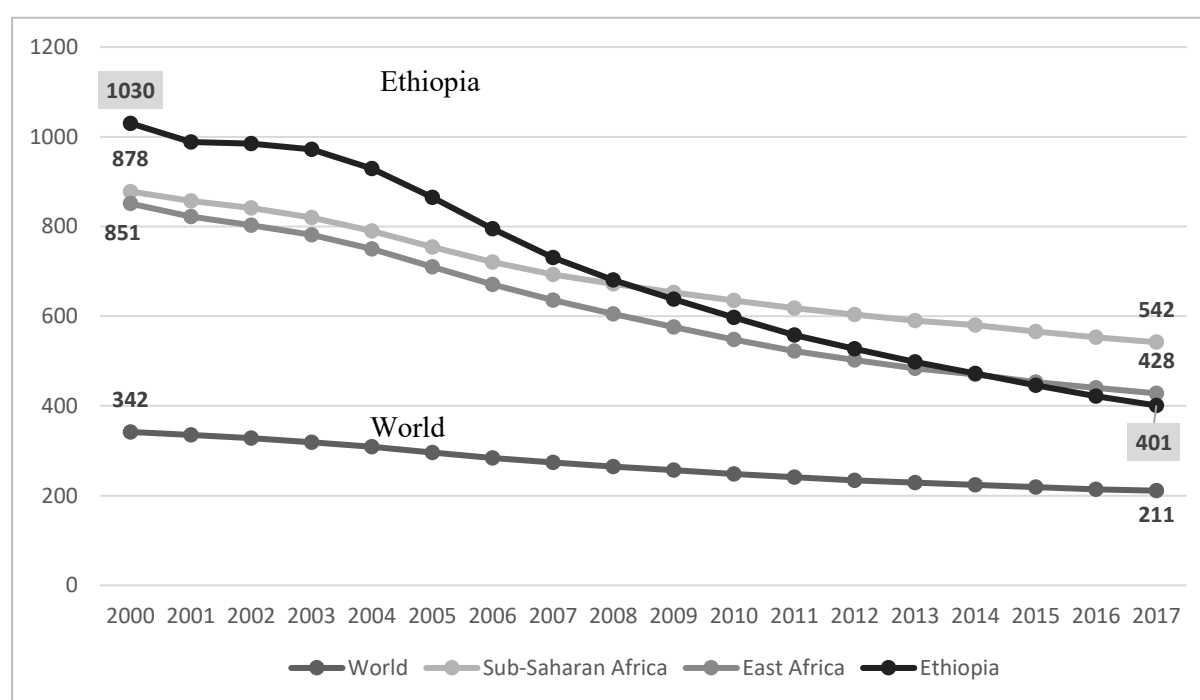


Figure 1.3. Maternal mortality ratios (per 100,000 live births) of the world, Sub-Saharan Africa, East Africa and Ethiopia between 2000 and 2017. Figure created from data available in the United Nations Global SDG database(13)

While there have been recent calls to expand the focus of women's health beyond the antenatal and postnatal periods (14), efforts to reduce maternal mortality remain relevant. Whether motivated by social justice aspirations or simply a recognition that sustainable development requires participation from both men and women alike, reducing maternal morbidity and mortality contributes to enhancing and preserving women's health.

Estimates of maternal mortality between 2000 and 2017 point to an overall decrease across the world including Sub-Saharan Africa, where maternal mortality has generally been concentrated (Figure 1.3).(15) Nevertheless, maternal mortality in Sub-Saharan Africa was 2.6 times higher than the world average in 2017.

Prior to 2008, estimates indicate that Ethiopia had MMRs that were among the highest in the world (Figure 1.3). By 2017, however, Ethiopia had reduced its MMR to 401 deaths per 100,000 live

births, which was lower than the average for both Sub-Saharan Africa (542 deaths per 100,000 live births) and Eastern Africa (428 deaths per 100,000 live births), where Ethiopia is located.

As shown in Figure 1.4, MMRs estimated using data from the 2011 Demographic and Health Survey (DHS) ranged from 234 deaths per 100,000 live births in the capital Addis Ababa to 743 deaths per 100,000 live births in Somali region.(16,17) Oromia region, where my thesis research was conducted, had an estimated 688 deaths per 100,000 live births, which was higher than the national average (676 deaths per 100,000 live births).

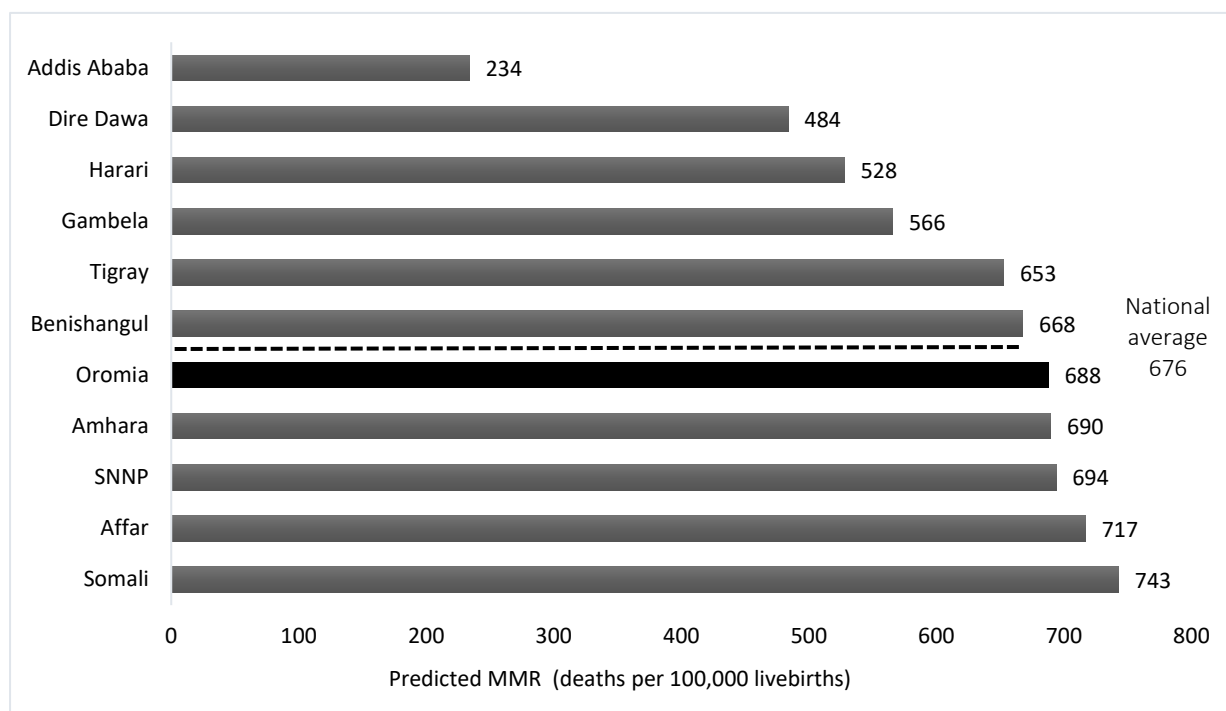


Figure 1.4. Predicted maternal mortality ratios per 100,000 live births by region in Ethiopia using 2011 DHS data (17)

Sub-national estimates have also demonstrated large variation in maternal mortality across regions of Ethiopia.(16) The MMR from an INDEPTH network Health and Demographic Surveillance System site in Kersa district – one of the study districts – was estimated to be 324 deaths per 100,000 live births between 2008 and 2014.(18)

1.3.1. Causes of maternal death

The absence of vital registration systems in low resource settings, particularly in Sub-Saharan Africa (19) , has made monitoring of maternal mortality and ascertaining causes of maternal death challenging. According to the World Bank and the WHO, 80% of all deaths in low resource settings occurred outside of the health system in 2012; however, 42 African countries did not have reliable death registration data.(20) While investments are being made to develop and scale up civil registration and vital statistics systems, global estimates are generated through modelling and/or aggregation of data

from surveys. Between 2003 and 2009, based on estimates using 417 datasets from 115 countries, direct obstetric causes accounted for almost three-quarters of all maternal deaths in the world; 27% were due to haemorrhage (more than two-thirds during the postpartum period), 14% due to hypertensive conditions (related to pregnancy such as pre-eclampsia) and 11% were as a result of pregnancy-related sepsis.(21) Stratification by region revealed a similar breakdown in Sub-Saharan Africa (25% haemorrhage, 16% hypertension and 10% sepsis). (21)

In Ethiopia, Tessema et al. determined causes of maternal death using data from the Global Burden of Disease database.(22) In 2013, almost 20% of maternal deaths were due to abortion-related complications; other causes included haemorrhage (12%), hypertensive disorders (10%), sepsis (10%) and obstructed labour (5%). Over a quarter of maternal deaths were due to a series of other direct causes such as anaesthesia complications and embolisms.(22) The majority of maternal deaths between 1990 and 2013 occurred during the postpartum period. In fact, verbal autopsy data from Kersa district exposed 47% of maternal deaths between 2008 and 2014 to be due to postpartum haemorrhage. Similar to national trends, other causes of maternal death were hypertensive disorders (16%), abortion-related complications (9%), sepsis (7%) and obstructed labour (2%).(18)

Looking more locally, a retrospective review of obstetric records at the Jimma University Hospital (which serves as a referral hospital in the Safe Motherhood Project study area) between 2002 and 2006 found the main causes of the 87 maternal death registered to be due to obstructed labour (35%), sepsis (26%) and abortion complications (15%).(23)

1.3.2. Factors associated with maternal mortality

Differences in maternal mortality along social and economic gradients, within and across countries, are often reported and raise concerns about underlying inequities. An ecological exploration of selected socio-economic indicators and maternal mortality across 45 countries in Sub-Saharan Africa found significant inverse correlations; higher MMRs were correlated with lower adult literacy (-0.52, $p < 0.001$), less prevalent contraceptive use (-0.62, $p < 0.001$), lower proportion of primary enrolment among females (-0.44, 0.01) and lower per-capita government expenditure on health (-0.45, $p = 0.002$). (24)

Associations between maternal mortality and the Women Peace and Security Index, which combines measures of “women’s inclusion, justice and security”(25), have also been examined for 105 countries. A one-point increase (improvement) in the index was found to be associated with a 2% decrease in the number of maternal deaths. The findings underscore the importance of factors associated with women’s empowerment and safety in maternal mortality and furthermore, highlight the need for a social determinants approach to making motherhood safer for women.

1.4. Safe Motherhood and Global Commitments

Maternal deaths in industrialized nations prior to the 20th century paralleled levels observed more recently in developing countries, particularly in Sub-Saharan Africa.(26) Advances in medicine, such as the discovery of antibiotics, and availability of midwife care, has partially been credited for the significant decline in maternal mortality in developed countries from the 1930s onwards.(27,28) Unfortunately, these successes did not translate into similar improvements across the globe, and low-income countries have sustained high maternal mortality rates.

1.4.1. Safe Motherhood Initiative

Early on, the global scale of maternal mortality was largely unknown because of the absence of reliable measures. However, estimates produced in 1985 WHO-UNFPA studies raised concern and galvanized action that resulted in the Safe Motherhood Initiative in 1987 led by the World Bank, WHO and United Nations agencies.(29) The primary aim of this initiative was to reduce maternal mortality.(30) A decade later, achievements under target were attributed in part to approaching maternal health as a component of child health without explicitly acknowledging the value in preserving the health of women themselves.(30) A lack of unified technical leadership and the divide among experts on whether to focus on access to emergency obstetric care (EmOC) or community level prevention also diminished political priority accorded to maternal health.(31) Subsequent reframing of maternal deaths as a social injustice put more onus on governments to act to protect human rights (including health rights) of their citizens.

The importance of widespread EmOC was recognised in the late nineties when it became apparent that the risk-selection approach to ANC adopted by the WHO in the 1970s was failing. This approach, which focuses on referring women with identifiable risk factors, such as short stature or high blood pressure, to health facilities, missed visibly healthy women who went on to experience obstetric complications.(32) However, despite Safe Motherhood Initiative commitments in 1997 to expand EmOC, the requisite increase in skilled birth attendants did not follow, resulting in persisting high maternal mortality rates.(32) The need to decentralize obstetric care to ensure rural populations also have adequate care levels was also highlighted by Maine and Rosenfield in their reflections on why the Safe Motherhood Initiative had achieved partial success.(33)

1.4.2. Millennium Development Goals

The adoption of the Millennium Declaration in 2000 by the countries in the United Nations General Assembly, and the inclusion of a goal explicitly devoted to maternal mortality reduction by 2015, represented a pivotal moment in Safe Motherhood history. The goal set for 2015 was to reduce the existing maternal mortality by 75% and was tracked using two indicators, one of which was the

proportion of births supported by skilled attendants.(34) Strategies to achieve Millennium Development Goal (MDG) 5 included “promoting community practices to support safe motherhood.....and monitoring maternal healthcare status and service access.”(35) The MDGs served as a global framework for development that facilitated resource allocation and policy priority setting within a specified period.(36) However, difficulties in establishing reliable baseline levels from which to measure progress, particularly for maternal mortality (37), and the reporting of national averages that masked sub-national inequalities period (36) were among some of the flaws of the MDGs. Most countries failed to meet the targeted reductions in maternal mortality.(38) Overall, there has been patchy and modest progress in reducing maternal mortality compared to child mortality. This may be due to the resource intense nature of requirements to reduce maternal mortality; providing obstetric care necessitates trained healthcare professionals and infrastructure.(39,40)

In Ethiopia, the MMR was described to have dropped by 71%, based on DHS survey estimates (2011 and 2016), bringing it close to achieving MDG5; skilled birth attendance was also reported to have increased nine-fold between 2000 and 2015.(41) However, Ethiopia did not launch a civil registration and vital statistics system to record births, deaths and marriages until 2016.(42) This meant that it relied on estimates to assess its performance with respect to maternal mortality. A 200% increase in total expenditure on health was also recorded between 2000 and 2015. However, this was mostly sourced through external aid and was still below the average of other Countdown countries³ being monitored; the per capita spending was also deemed to be quite low.(43)

1.4.3. Sustainable Development Goals

The Sustainable Development Goals (SDGs) were adopted by the United Nations General Assembly in 2015 to continue work begun with the MDGs. The 17 goals formulated include 12 that are indirectly related to health. The specific health goal (SDG3) to “ensure healthy lives and promote well-being for all at all ages”, includes a target to attain a global MMR of 70 deaths per 100,000 live births by 2030 (target 3.1) and uses the same indicators as MDG5 to monitor progress.(44) Unlike the MDGs, however, there is strong emphasis on ensuring equity in progress; SDG3 also includes targets to attain universal health coverage and achieve universal access to sexual and reproductive healthcare services.(45)

For countries that did not achieve targeted reductions in maternal mortality during the MDG period, there is a strong need to accelerate reductions in annual mortality rates in order to meet SDG targets. There is an equal need to improve women’s access to education and to facilitate their

³ Countdown to 2015 was an initiative to track progress in attaining MDG4 and MDG5 in 75 countries where the majority of maternal and child deaths were registered. In partnership with The Lancet, 43 academic and other civil society institutions compiled data using 73 indicators for countries being monitored. Ethiopia was among the case study countries examined in depth on various aspects to better understand its progress and make recommendations based on challenges experienced in meeting targets.

empowerment.(46) The focus on national averages has tended to conceal substantial variation across geographical areas and population sub-groups within countries. Strategies prioritized for ending preventable mortality include health system strengthening, engaging communities, improving data for decision making and minimizing inequities in access to care.(46)

1.5. Maternal mortality and access to maternal healthcare

The above commitments stress the importance placed on the link between maternal mortality and access to quality maternal healthcare services for all. Correlations between low coverage of essential interventions, such as skilled birth attendance, and high maternal mortality have been demonstrated in several countries including Ethiopia.(24,47)

The rationale for promoting skilled attendance at birth centres on the fact that a large proportion of maternal deaths occur during and within 48 hours of delivery. Therefore, the presence of healthcare professionals to manage complications should reduce maternal mortality.(48,49) Data from historical sources as well as findings from observational and quasi-experimental studies support this view, although they cannot be used to make any causative conclusions.(48) Nevertheless, the WHO emphasizes the importance of having skilled care “before, during and after childbirth” and its role in averting maternal and newborn deaths.(50)

Perhaps more important is the consistent pattern of higher mortality and lower access to essential maternal healthcare services observed among the poorest women within countries.(51) Additionally, rural women generally experience certain access issues more acutely than urban populations (52); this may be due to comparatively poor road infrastructure, reduced transport options and less financial resources in rural areas.(53) This has prompted repeated calls for expanding coverage of essential interventions and targeting support for women living in disadvantaged circumstances.(26,54–56) Attaining “grand convergence”(57) in maternal health can benefit from strategic identification of all those being left behind to ensure effective coverage levels.

1.6. Access to care and service utilization

Improving access to care and addressing barriers requires being able to ascertain levels of access. The concept of access needs to be clearly articulated to enable measurement. Access has been conceptualized in several different ways, with each definition encompassing slightly different dimensions.(58,59)

Aday and Andersen formulated a model for examining access as originating from policy objectives and being influenced by characteristics of both the health system delivering care as well as the attributes of the population; utilization of services and consumer satisfaction are viewed as outcomes of access in their model.(60)

Donabedian describes accessibility in terms of services being available and attributes that enable or deter use of services by individuals.(61) However, an emphasis is placed, once again, on use representing successful access (“the proof of access is use of service, not simply the presence of a facility”).(62) Donabedian also makes a distinction between the “initiation” of service use and “continuation” of use which may be influenced by different factors.

Penchansky & Thomas devised the “5As” concept of access where availability, accessibility, accommodation, affordability and acceptability are dimensions of access. These were considered important factors in determining how well the health system aligned with users, thus influencing access to care.(63) Others have extended this model to include five additional dimensions exploring ability of populations to “generate access” (ability to perceive, to seek, to reach, to pay and to engage).(64)

In my thesis, the use of various types of maternal healthcare services (as reported by women) function as central outcomes of interest. I adopt the perspectives assumed by Aday & Andersen(60) as well as Donabedian(62), where use serves as a proxy for access. I explore factors associated with service use at various levels to shed light on barriers women face when attempting to access maternal healthcare services; I also draw on some aspects of ability described by Levesque such as “ability to perceive” (ex: danger sign knowledge) and “ability to reach” (ex: distance to facility).(64)

1.7. Chapter summary

My overall research goals are to contribute to the understanding of what factors, particularly those that operate in women’s geographical and social contexts, influence maternal healthcare service use; and to determine whether or not MWHs⁺ and training local leaders can improve delivery care use in rural Ethiopia. These goals are motivated by global efforts to reduce maternal mortality that have a long history and that emphasize access to care as being one of the ways to end preventable maternal mortality and morbidity. I adopt a social ecological lens when considering what factors affect women’s abilities to access services to capture influences beyond individual characteristics and household factors.

In the next chapter, I describe the healthcare system in Ethiopia through which ANC, MWH, delivery care and PNC services are provided and, define and examine the levels of utilization of these services in Ethiopia. I also provide a summary of extant literature on determinants of maternal healthcare service use. I end the chapter by outlining what is known about the effectiveness and use of MWHs, the intervention component of primary focus in my thesis. I also briefly touch on the role of community and religious leaders in improving access to maternal healthcare services.

1.8. Chapter references

1. International Development Research Centre. Innovating for Maternal and Child Health in Africa [Internet]. [cited 2020 Mar 30]. Available from: <https://www.idrc.ca/en/initiative/innovating-maternal-and-child-health-africa>
2. Gebretsadik LA, Labonté R, Bedru KH, Morankar S, Kulkarni M, Spitzer D, et al. An Implementation Study of Interventions to Promote Safe Motherhood in Jimma Zone, Ethiopia. Jimma & Ottawa; 2015.
3. Golden SD, Earp JAL. Social Ecological Approaches to Individuals and Their Contexts: Twenty Years of Health Education & Behavior Health Promotion Interventions. *Heal Educ Behav*. 2012;39(3):364–72.
4. Glanz K, Bishop DB. The Role of Behavioral Science Theory in Development and Implementation of Public Health Interventions. *Annu Rev Public Health*. 2010;31:399–418.
5. McLeroy KR, Bibeau D, Steckler A, Glanz K. Ecological Perspective on Promotion Programs. *Health Educ Q*. 1988;15(4):351–77.
6. World Health Organization. Closing The Gap in a Generation. Health equity through action on the social determinants of health. Geneva; 2008.
7. Solar O, Irwin A. A Conceptual Framework for Action on the Social Determinants of Health. Social Determinants of Health Discussion Paper 2 (Policy and Practice). Geneva; 2010.
8. Marmot M. Social determinants of health inequalities. *Lancet*. 2005;365:1099–104.
9. Federal Democratic Republic of Ethiopia Ministry of Health. National Reproductive Health Strategy (2016-2020). Addis Ababa; 2016.
10. Melberg A, Diallo AH, Ruano AL, Tylleskär T. Reflections on the unintended consequences of the promotion of institutional pregnancy and birth care in Burkina Faso. *PLoS One*. 2016;11(6):e0156503.
11. Thaddeus S, Maine D. Too far to walk: maternal mortality in context. *Soc Sci Med*. 1994;38(8):1091–110.
12. Health statistics and information systems [Internet]. [cited 2020 Feb 5]. Available from: <https://www.who.int/healthinfo/statistics/indmaternalmortality/en/>
13. United Nations. SDG Indicators [Internet]. United Nations Global SDG Database. 2020 [cited 2020 Apr 2]. Available from: <https://unstats.un.org/sdgs/indicators/database/>
14. Langer A, Meleis A, Knaul FM, Atun R, Aran M, Arreola-ornelas H, et al. Women and Health: the key for sustainable development. *Lancet*. 2015;386:1165–210.
15. World Health Organization. Trends in Maternal Mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank and UN Population Division. Geneva; 2019.
16. UNFPA. Trends in Maternal Health in Ethiopia Challenges in achieving the MDG for maternal mortality. Addis Ababa; 2012.
17. Ethiopia Demographic and Health Survey (2011). Addis Ababa & Calverton; 2012.
18. Tesfaye G, Loxton D, Chojenta C, Assefa N, Smith R. Magnitude, trends and causes of maternal mortality among reproductive aged women in Kersa health and demographic surveillance system, eastern Ethiopia. *BMC Womens Health*. 2018;18(198).
19. Setel PW, Macfarlane SB, Szreter S, Mikkelsen L, Jha P, Stout S, et al. A scandal of invisibility: making everyone count by counting everyone. *Lancet*. 2007;370(9598):1569–77.
20. World Bank, World Health Organization. Global Civil Registration and Vital Statistics Scaling up Investment Plan 2015 – 2024. 2014.

21. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller A, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Heal*. 2014;2:e323-33.
22. Tessema G, Laurence C, Melaku YA, Misganaw A, Woldie S, Hiruye A, et al. Trends and causes of maternal mortality in Ethiopia during 1990–2013: findings from the Global Burden of Diseases study 2013. *BMC Public Health*. 2017;17(160).
23. Negussie D, Mesfin N. Review of maternal death in Jimma University Specialized Hospital. *Ethiop J Heal Sci*. 2009;19(1):9–12.
24. Alvarez JL, Gil R, Hernández V, Gil A. Factors associated with maternal mortality in Sub-Saharan Africa: an ecological study. *BMC Public Health*. 2009;9(462).
25. Klugman J, Li L, Barker KM, Parsons J, Dale K. How are the domains of women's inclusion, justice, and security associated with maternal and infant mortality across countries? Insights from the Women, Peace, and Security Index. *SSM-Population Heal*. 2019;9(100486).
26. De Brouwere V, Van Lerberghe W, editors. *Safe Motherhood Strategies*. Antwerp: ITG Press; 2001.
27. Loudon I. Maternal mortality in the past and its relevance to developing countries today. *Am J Clin Nutr*. 2000;72(1 SUPPL.).
28. Chamberlain G. British maternal mortality in the 19th and early 20th centuries. *J R Soc Med*. 2006;99:559–63.
29. Rosenfield A. The history of the Safe Motherhood Initiative. *Int J Gynecol Obstet*. 1997;59(SUPPL. 2):7–9.
30. AbouZahr C. Safe Motherhood: a brief history of the global movement 1947 – 2002. *Br Med Bull*. 2003;67:13–25.
31. Shiffman J, Smith S. Generation of political priority for global health initiatives: a framework and case study of maternal mortality. *Lancet*. 2007;370:1370–9.
32. Bergstrom S. Global maternal health and newborn health: Looking backwards to learn from history. *Best Pract Res Clin Obstet Gynaecol*. 2016;36:3–13.
33. Maine D, Rosenfield A. The Safe Motherhood Initiative: Why Has It Stalled ? *Am J Public Health*. 1999;89:480–2.
34. United Nations. *The Millenium Development Goals Report*. New York; 2015.
35. Road map towards the implementation of the United Nations Millenium Declaration. Report of the Secretary General. 2001.
36. UN System Task Team. Review of the contributions of the MDG Agenda to foster development: lessons for the post-2015 UN Development Agenda. 2012.
37. Attaran A. A criticism of the Millennium Development Goals and why they cannot be measured. *PLoS One*. 2005;2(10).
38. World Bank, UNDP. *Transitioning from the MDGs to the SDGs*. New York & Washington; 2016.
39. Moucheraud C, Owen H, Singh NS, Ng CK, Requejo J, Lawn JE, et al. Countdown to 2015 country case studies : what have we learned about processes and progress towards MDGs 4 and 5 ? *BMC Public Health*. 2016;16 (Suppl(794).
40. Bhutta ZA, Black RE. Global Maternal, Newborn, and Child Health — So Near and Yet So Far. *N Engl J Med*. 2013;369:2226–35.
41. Assefa Y, Damme W Van, Williams OD, Hill PS. Successes and challenges of the millennium development goals in Ethiopia: lessons for the sustainable development goals. *BMJ Glob Heal*. 2017;2(2):e000318.

42. UNICEF. First ever registration and vital statistics day observed in Ethiopia [Internet]. Addis Ababa; 2018 [cited 2019 Jul 30]. Available from: <https://www.unicef.org/ethiopia/press-releases/first-ever-civil-registration-and-vital-statistics-day-observed-ethiopia>
43. Mann C, Ng C, Akseer N, Bhutta ZA, Borghi J, Colbourn T, et al. Countdown to 2015 country case studies: what can analysis of national health financing contribute to understanding MDG 4 and 5 progress? *BMC Public Health*. 2016;16 (Suppl(792)).
44. United Nations. SDG Indicators.
45. Brizuela V, Tunçalp Ö. Global initiatives in maternal and newborn health. *Obstet Med*. 2017;10(1):21–5.
46. Lawn JE, Blencowe H, Kinney M V, Specialist S, Bianchi F, Graham WJ. Evidence to inform the future for maternal and newborn health. *Best Pract Res Clin Obstet Gynaecol*. 2016;36:169–83.
47. Requejo JH, Victora CG, Barros AJD, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Geneva, Switzerland; 2015.
48. Graham, W. J., Bell, J. S., & Bullough CH. Can skilled attendance at delivery reduce maternal mortality in developing countries. *Stud Heal Serv Organ Policy*. 2001;17:97–130.
49. De Bernis L, Sherratt DR, AbouZahr C, Van Lerberghe W. Skilled attendants for pregnancy, childbirth and postnatal care. *Br Med Bull*. 2003;67:39–57.
50. World Health Organization. Maternal mortality [Internet]. [cited 2020 Apr 6]. Available from: <https://www.who.int/news-room/fact-sheets/detail/maternal-mortality>
51. Requejo JH, Bhutta ZA. The post-2015 agenda: staying the course in maternal and child survival. *Arch Dis Child*. 2015;100 (Suppl:s76–81).
52. Say L, Raine R. A systematic review of inequalities in the use of maternal health care in developing countries: examining the scale of the problem and the importance of context. *Bull World Heal Organ*. 2007;85:812–9.
53. Kyei-Nimakoh M, Carolan-Olah M, McCann T V. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. *Syst Rev*. 2017;6(110).
54. Moore M. Safer Motherhood, Safer Womanhood. Geneva; 2002.
55. Kinney M V, Kerber KJ, Black RE, Cohen B, Nkrumah F, Coovadia H, et al. Sub-Saharan Africa’s Mothers, Newborns, and Children: Where and Why Do They Die ? *PLoS Med*. 2010;7(6):e1000294.
56. Chou D, Daelmans B, Jolivet RR, Kinney M, Say L. Ending preventable maternal and newborn mortality and stillbirths. *BMJ*. 2015;351 (Suppl:19–22).
57. Jamison DT, Summers LH, Alleyne G, Arrow KJ, Berkley S, Binagwaho A, et al. Global health 2035: a world converging within a generation. *Lancet*. 2013;382:1898–955.
58. Cornelius LJ, Banks KA, Mullner RM. Models of Access. In: Mullner RM, editor. *Encyclopedia of Health Services Research*. Thousand Oaks: SAGE Publications Inc; 2009. p. 14–8.
59. Gulliford M, Figueroa-Munoz J, Morgan M, Hughes D, Gibson B, Beech R, et al. What does “access to health care” mean? *J Health Serv Res Policy*. 2002;7(3):186–8.
60. Aday LA, Andersen R. A Framework for the Study of Access to Medical Care. *Health Serv Res*. 1974;9(3):208–20.
61. Puentes-Markides C. Women and access to health care. *Soc Sci Med*. 1992;35(4):619–26.
62. Donabedian A. Models for Organizing the Delivery of Personal Health Services and Criteria

- for Evaluating Them. *Milbank Mem Fund Q.* 1972;50(4):103–54.
63. Penchansky R, Thomas JW. The concept of access: definition and relationship to consumer satisfaction. *Med Care.* 1981;19(2):127–40.
 64. Levesque J-F, Harris MF, Russell G. Patient-centred access to health care: conceptualising access at the interface of health systems and populations. *Int J Equity Health.* 2013;12(18).

Chapter 2. Background

2.1. Overview of healthcare system in Ethiopia

2.1.1. Political context in which maternal healthcare developed

Community-based primary healthcare is an attractive option for countries that have a substantial rural population as it is one way to ensure equitable healthcare.(1) Ethiopia, with 80% of the population residing in rural areas (2), is committed to community-based primary healthcare, but political instability and resource shortages have hindered progress. In recent decades, Ethiopia has experienced a series of droughts and famines, armed conflict with Eritrea and Somalia, and internal civil war.(1,3)

Between 1930 and 1974, Ethiopia was a feudalist regime under the rule of Emperor Haile Sellassie. It was during Sellassie's reign that primary healthcare began to take shape in Ethiopia - the Ministry of Public Health was established in 1947 and the first national policy and strategy for health was created in 1963.(1) One of Sellassie's attempts to "modernize" Ethiopian communities involved the construction of maternity wards in urban hospitals and rural health centres; but campaigns to replace traditional practices with facility-based antenatal and delivery care were largely resisted and generally failed.(4) Despite plans to decentralize basic health service delivery using health centres and health stations, resources necessary to realize this were not allocated. Health professionals were concentrated in the capital, Addis Ababa, and hospitals received over 90% of total expenditure on health in 1972.(1)

The *Derg* regime, which assumed power after a military coup in 1974, operated on socialist principles and, therefore, supported the Alma Ata declaration on primary health care. Their '10-Year Perspective Health Plan' included expansion of maternal and child health services as part of the health system's core objectives. A six-tiered health system with an emphasis on community participation included "community health services" run by community health agents.(1) During this time, *woredas* (districts) and *kebeles* (villages) were also created.(5) The model of Ethiopian Socialism (*Hebretesabawinet*) adopted by the *Derg* regime had self-reliance as one of its foundational principles; an education and empowerment campaign, the *Zemecha*, was launched to equip the population with literacy and arithmetic skills.(6) During this time, more than half of the nation's clinics were constructed and over 1,500 midwives were trained.(7) Despite a positive start, by 1990 only 3% of the national budget was allocated to health and the "mass organizations....turned into an instrument for political control".(1) Men, particularly those who were members of farmer/labourer associations or other government created organizations, had better access to health services than non-members, women and ethnic minorities. Elitist attitudes adopted by administrators, which have been described as viewing the

population as “...ignorant peasants...there to be organized...taxed.....governed”(8), increased social barriers that hindered service utilization.(1,8)

In 1991, the *Derg* regime was replaced by the transitional government formed by a coalition of “rebels”, such as the Ethiopian People’s Democratic Revolutionary Front and the Oromo Liberation Front, who challenged what had become for many an oppressive regime. Ethiopia transitioned to a free-market economy and decentralized political power to nine autonomous states with their own constitutions. Unfortunately, by this time many health facilities were non-functional and service use was very low; the proportion of women delivering at health facilities, for instance, was only 6%.(1) Regional health departments were allocated the responsibility of planning and implementing health programs to meet nationally set targets in line with national policies; halving infant and under-five mortality was prioritized during this time. Zonal health offices were also created and additional health workers trained and mobilized, but no new health facilities were built as funds were earmarked for the large numbers requiring repair.(1)

2.1.2. Health Sector Development Plans

The first national health policy was formulated in 1993 under Transitional Government and formed the basis for the Health Sector Development Plans (HSDPs) that guided health service restructuring in the two decades that followed.(9,10) Objectives of the policy included decentralization and expansion of primary healthcare services towards equitable access, particularly in rural areas. Devolution of authority was staggered beginning at the regional level in 1996 and followed by the *woreda* level in 2002.(11) *Woreda* health offices are responsible for health service delivery and management; they create their own budgets using regional government grants and are expected to handle health facility construction, procurement, personnel recruitment including health extension workers (HEWs) and to mobilize the community to use health services and contribute resources as needed.(11)

The first HSDP was rolled out in 1997 as part of larger development plans including the ‘Plan for Accelerated and Sustained Development to End Poverty’ and the ‘Growth and Transformation Plan’.(12) Failure to achieve targets in HSDP I (1997-2002) led to the introduction of non-governmental organizations as implementation partners in HSDP II (2003-2005). Further collaboration and an expansion of implementation scope to the *woreda* level was integrated into HSDP III (2006-2009) as was an increase in national health spending.(9)

Throughout the Development Plan cycles, an emphasis has been placed on increasing both health infrastructure and health human resources. In 2006, the World Health Organization (WHO)

estimated that densities of at least 2.28 skilled health workers per 1,000 population were needed to achieve 80% coverage of skilled birth attendance.(13) Moreover, in order to meet the current Sustainable Development Goal (SDG) target of universal health coverage, 4.45 skilled health workers per 1,000 population will be needed.(14) At the commencement of Health Sector Transformation Plan V (2016-2020), Ethiopia had a skilled health worker to population ratio of 0.7 per 1,000 population which was well-under its own target of 2.3 per 1,000 (15) and the WHO recommended density.

As part of healthcare financing reforms introduced in 2005, maternal healthcare services such as antenatal care (ANC), delivery services and postnatal care (PNC) were declared exempt from user fees charged at health centres and health posts. However, since these facilities are not reimbursed for the free services provided, they tend to impose other user charges such as card fees¹ or require women to purchase supplies needed for delivery.(16) Of more concern was that 20% of facilities assessed in 2009 national survey were found to demand upfront payments before they would attend to obstetric emergencies.(16)

2.1.3. Service delivery structure

At present (including the research period), health services in Ethiopia are delivered using a three-tiered system. Primary healthcare is provided at the lowest tier consisting of primary health care units (PHCUs). (15) As illustrated in Figure 2.1, each PHCU comprises a health centre and around five community-based health posts in rural areas (urban areas rely on health centres alone). Health posts are usually staffed with two HEWs and generally serve 3,000 to 5,000 households. Health centres provide both preventive and curative services including ANC, delivery care and PNC. They are responsible for 15,000 to 25,000 households in rural areas (40,000 households in urban areas).(15) They typically have an inpatient capacity of five beds. Tier 1 also includes a primary hospital with a 25-50 bed capacity to which complicated cases encountered at health centres are referred.(15) Primary hospitals offer 24-hour emergency services and are expected to be able to provide comprehensive emergency obstetric care.(17) In 2014, the median number of providers at primary hospitals surveyed in Ethiopia included five general practitioners, four health officers and six midwives. About half the health centres had two health officers each.(17)

The second tier includes a general hospital (Figure 2.1) that has both inpatient and ambulatory services and typically serves a million people. General hospitals function as referral facilities for

¹ Women are often charged a registration fee before receiving services (16) and these indirect costs have been reported to be a barrier to maternal healthcare service use in Ethiopia. (222) In some contexts, securing an ANC card is viewed as “insurance” for birth as possession of the card makes it easier for women to use delivery care services(92) and not be labelled as service defaulters.

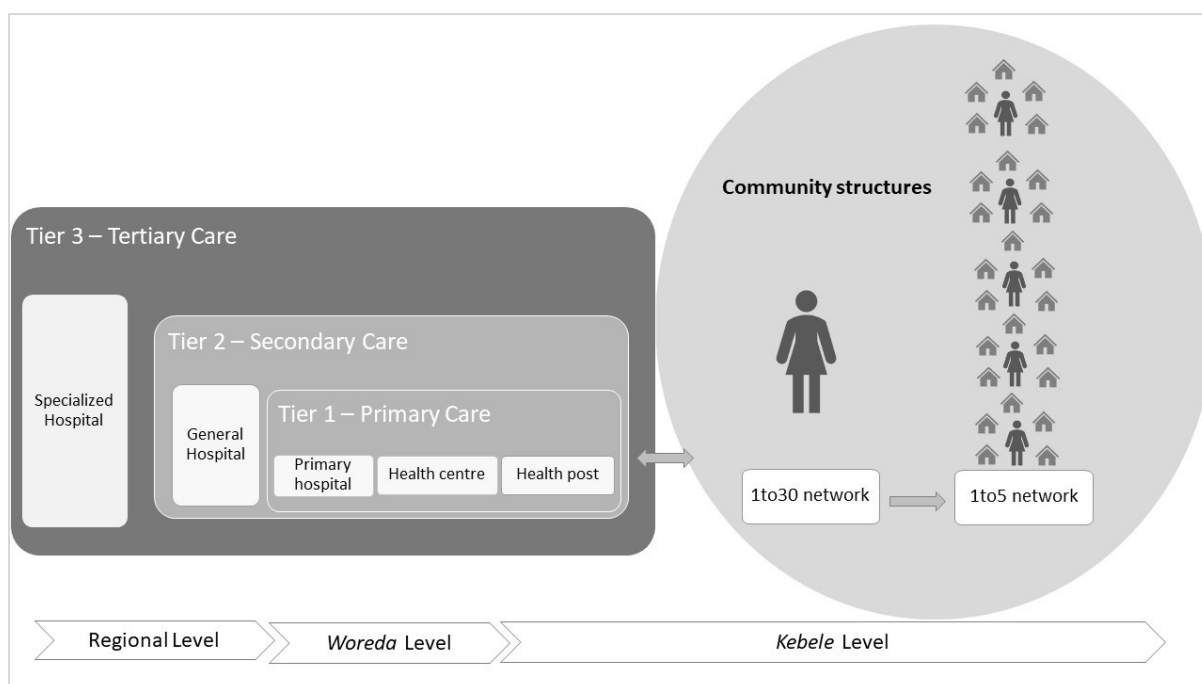


Figure 2.1. Structure of the health system in rural Ethiopia. Figure adapted from HSTP V(15) and the Emergency Nutrition Network blog(18)

primary hospitals. In 2014, general hospitals had a median of four medical specialists (ex: general surgeons, anaesthesiologists, obstetricians, etc).(17) The final tier consists of a specialized hospital responsible for five million people. In 2016, there were a total of 3,804 health facilities in Ethiopia including 30 specialized hospitals, 103 general hospitals, 160 primary hospitals and 3,459 health centres; Oromia region had a total of 1,405 health facilities comprising 7 specialized hospitals, 25 general hospitals, 41 primary hospitals and over 35% of the country's health centres.(19)

Facilities at various levels of the health system are connected through a referral system, although this does not always function optimally. A cross-sectional study conducted in three regions in Ethiopia in 2014 found that just 10% of individuals seeking care at a health centre or hospital had been referred; 40% of those sampled at hospital level had come for routine maternal and child healthcare, but had bypassed services available at primary care facilities such as health posts and health centres.(20)

The potential of community health workers to “create a bridge between health providers and the community”, particularly in low resource settings where the available number of health workers often falls short of the need, has long been recognized.(21) In Ethiopia, community structures have been designed to accelerate access to primary healthcare as part of universal health coverage efforts.(22) These include the Health Extension Program and the Women's Development Army (WDA). The Health Extension Program, launched in 2003, includes reduction in maternal and child mortality as one of its objectives. A series of 16 modules is implemented by HEWs as part of the program to encourage

households to take charge of their health and well-being. The modules provide information on appropriate hygiene and feeding practices, malaria prevention, and vaccination, and encourage health facility utilization among other topics.(23) HEWs are women recruited by *kebele* councils from the communities they are charged to serve. They must have completed at least Grade 10 and receive one year of training before being deployed to health posts and provided with a salary.(24) HEWs are expected to conduct outreach activities, provide preventive services at the health post and make referrals. They are also expected to collect information about households within their catchment including the number of women of reproductive age, number of women who are pregnant, and women who have used antenatal and delivery care services.(25)

HEWs are supported by members of the WDA, a program that was initiated in 2011 to further expand geographical coverage of primary healthcare.(26) Members are organized into 1-to-5 (*toko shanee*) and 1-to-30 networks as part of the diffusion model approach to behaviour change. *Toko shanees* are made up of five households that are led by a WDA member who is responsible for sharing and modelling the content of the Health Extension Program modules after receiving training from HEWs.(26,27) Five *toko shanees* are organized into a 1-to-30 network with a leader (Figure 2.1) who works closely with HEWs. Households that are able to successfully implement all aspects covered in the Health Extension Program graduate as “model families” expected to be emulated by neighbouring households. In 2015, there were about three million model families in Ethiopia and mobilization of community funds through the WDA enabled the purchase of 200 ambulances to supplement those purchased at the *woreda* level.(22) Model families influence their peers by promoting Health Extension Program content at informal social activities like coffee ceremonies or at meetings of community associations such as the funeral fund collective (the *Iddir*). (27) Health centres support HEWs and community structures as part of their mandate laid out in the Ethiopia Health Centre Reform Implementation Guidelines, created by the Federal Ministry of Health in 2016.(28)

2.1.4. Emergency obstetric care (EmOC) capacity in Ethiopia

The rationale for increasing national capacity to provide EmOC is that it is one way to reduce maternal mortality.(29) Signal functions are a list of important medical interventions necessary to manage the direct obstetric complications responsible for most maternal deaths.(29) Signal functions are often used to evaluate the capacity of health facilities to provide basic EmOC or comprehensive EmOC. The main difference between basic and comprehensive EmOC services is that under the latter surgical care and blood transfusions are also available. A list of signal functions and the complications they address is provided in Appendix 2.1.

A global review conducted in 2014 reported a 55% unmet need for emergency obstetric care in the world and estimated that 951 million women did not have access to EmOC.(30) In Ethiopia, a national EmOC service assessment conducted in 2016 found that only 6% of health centres were fully functional in that they provided all seven basic EmOC signal functions. This proportion was higher at the hospital level where 14% provided basic EmOC and 45% provided comprehensive EmOC. In Oromia region, where the study districts are located, comprehensive EmOC capacity at hospital level was slightly higher (61%) than the national average but basic EmOC at hospital (13%) and health centre levels (4%) was comparable to the low national averages.(19)

Estimated unmet need for EmOC² was also found to be very high at 82% in 2016, meaning at a national level only 18% of women expected to have complications delivered at a health facility with appropriate obstetric care. This varied widely between regions, ranging from 17% unmet need in Addis Ababa to 97% unmet need in Gambella (in the eastern part of the country bordering Sudan). Oromia region had an unmet need (86%) that was slightly higher than the national average, ranking it among the regions with high unmet needs.

Health facilities vary in the signal functions that they fail on. In 2016, health centres were found to fall short in provision of parenteral antibiotics (61%), removal of retained products (34%) and assisted vaginal delivery (44%).(19) In terms of quality of delivery care, only 64% of health centres had electricity and 39% had functioning water sources in the labour room; 21% had fuel for ambulances to transport women and babies if necessary and 49% provided meals to women. Only 42% of health centres had an average length of stay after delivery of at least 24 hours.(19) Photographs of typical labour rooms at health centres in the study districts are included in Appendix 2.2.

2.2. Definitions of maternal healthcare services

2.2.1. Antenatal care

ANC is care received by pregnant women and girls from skilled healthcare workers to protect the well-being of both mothers and babies. This is generally achieved through risk prevention activities, health education, and detection and management of pregnancy-related diseases or complications.(31) In 2016, the WHO revised the minimum number of antenatal contacts from four (under the 2002 focused ANC model) to eight. Under the eight-contact schedule, women are expected to have their first contact during the first trimester, two contacts during the second trimester and five in the last trimester.

² Unmet need was estimated by comparing the number of reported direct obstetric complications to the 15% expected among the total births. The regional-specific figures may partially reflect referral patterns where more complicated cases tend to be forwarded to higher-level, specialized facilities such as those located in the capital city, Addis Ababa. Under-reporting at some facilities in rural regions may also over-estimate unmet need slightly.(19)

Components recommended for all women during the eight contacts include items such as nutritional counselling, iron and folic acid supplementation, maternal assessments such as hyperglycaemia tests and a 24-week ultrasound scan, and preventive measures such as the tetanus toxoid vaccination.(31)

Prior to the policy change, ANC use was generally assessed using two indicators: (i) the proportion of women who reported receiving ANC at least once during their last pregnancy and, (ii) the proportion of women who reported having receiving ANC at least four times during their last pregnancy.³ (32–34) Skilled healthcare professionals generally include doctors, nurses, midwives, clinical officers and community health workers trained to provide some aspects of ANC depending on country context.(33) When reporting ANC coverage during the Millennium Development Goal era, the WHO also adopted similar definitions for ANC.(35,36) In Ethiopia, the Demographic and Health Survey (DHS) program also relies on these two indicators to report ANC use; the indicators are constructed using several questions put to women about whether they received any ANC or not, whom they saw and where they sought care from.(37) Whether the skilled healthcare provider from whom service is obtained is specified or not depends on data availability.(38)

2.2.2. Delivery care

Several definitions covering slightly different aspects of delivery care exist. The WHO refers to the proportion of births occurring at health facilities as “institutional births”⁴ or “institutional deliveries”.(34) This definition operates under the assumption that women delivering at a health facility are likely to have been attended to by a skilled health worker trained to manage uncomplicated deliveries and refer complicated ones (34), although this may not always be the case.(39) This indicator has also been referred to as facility birth (40) and facility-based delivery.(41) Traditional birth attendants, whether trained or not, are not considered appropriate providers for delivery care.(33)

The DHS questionnaire includes two questions, about the site where the child was delivered and the people present during the birth, to generate variables pertaining to delivery care received.(37) The proportion of births attended by a skilled health professional is also one of the Sustainable Development Goal indicators related to the third goal pertaining to health and well-being. (42)

One limitation associated with the different definitions of delivery care is the potential discrepancy between skills that trained health workers should theoretically have and the actual skills

³ In my thesis, I use generally use one or both of these indicators.

⁴ I chose to use “institutional births” to refer to births reported by women to occur at health facilities that are expected to offer at least some level of basic emergency obstetric care such as hospitals and health centres, but not health posts. I use the term “delivery care” to mean obstetric services offered at hospitals or health centres to labouring women during the birth of their babies.

they have when practically assessed.(43) Additionally, when self-reported responses are relied upon from household survey data in low-resource settings, there are also limitations in women's ability to distinguish between various health worker cadres. (44)

2.2.3. Postnatal care

The postnatal or postpartum period is generally considered to cover the six weeks following birth. The WHO recommends four postnatal contacts with the first occurring within 24 hours of birth; additional visits are recommended at 48-72 hours, 7-14 days and six weeks post-delivery.(45) Both women and newborns are at highest risk of death and complications during this period.(46) PNC guidelines cover care recommended for both mothers and newborns; assessments of the baby include items such as its ability to feed, its breathing and its temperature. Mothers are typically assessed for bleeding, infection, pain, etc. (45)

PNC service use can be measured using several indicators depending on contact timing (i.e., within 24 hours, other contacts or all recommended contacts) and target (i.e mother or newborn or both). The DHS program measures the percent of women who receive postnatal checks during the first two days from health workers, community health workers or traditional birth attendants.(47) Separate indicators describing the type of provider present for the first PNC check for women and for newborns are also present. When relying on self-reported responses from household surveys, one of the limitations is the potential overestimation of PNC among women who delivered at a health facility who may not be able to distinguish between intrapartum and postpartum checks by healthcare professionals.(48)

Specific operational definitions used in the thesis are included in the methods section of each article.

2.3. **Status of maternal healthcare service use in Ethiopia**

2.3.1. Changes in service frequency and providers over time

Levels of utilization of ANC, delivery and PNC have been steadily increasing in Ethiopia as shown by DHS data between 2000 and 2019. The national averages in 2000 were 27% for ANC, 5% for delivery care and 11% for PNC (49) but increased to 74%, 50% and 34% respectively by 2019.(50) Similar increasing trends have been noted for Oromia region, with utilization levels of ANC being the highest and PNC the lowest. (Figure 2.2)

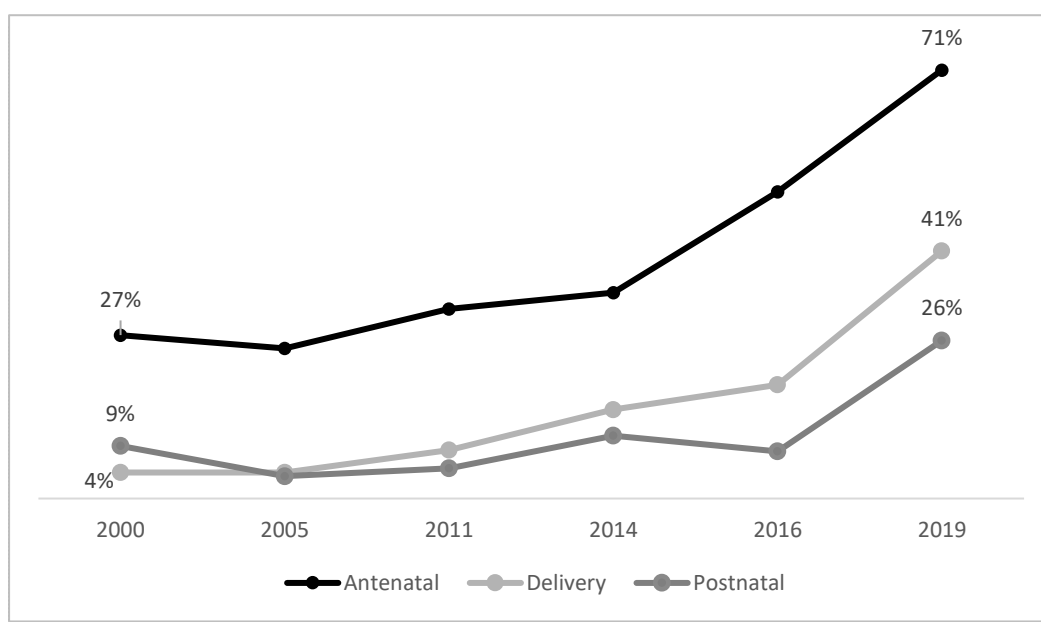


Figure 2.2. Levels of maternal healthcare service use between 2000 and 2019 in Oromia region. Figure generated using data from DHS reports (ANC corresponds to having at least one contact with a skilled provider; delivery care refers to the proportion of live births in the 5 years preceding the survey that occurred at a health facility; PNC refers to the proportion of women giving birth in the preceding two years that had a postnatal check within the first two days after birth).(49–54)

While ANC use, when measured as at least one visit, has generally been higher than other service use in Ethiopia, it is much lower when the proportion of women reporting four or more visits⁵ is considered. Nevertheless, the number of women reporting at least four ANC contacts has increased between 2000 (10%) and 2019 (43%).(49,50) Pregnant women have also tended to begin using ANC in their second trimester rather than in their first trimester as recommended, and this has only marginally improved over time.(54)

The proportion of births attended by skilled professionals has been on the rise since 2000.(49,54) However, the majority of these births are assisted by nurses and midwives rather than doctors. In 2016 for example, only 20% of births were attended by doctors although the proportion is much higher in private facilities compared to government facilities.(54) A shift in policy around clean and safe delivery at health posts may also have affected the profile of providers attending to births. Initially HEWs were trained to support uncomplicated deliveries at health posts (55–57), but this policy was later discontinued(58) possibly over concerns about the inability of all HEWs to perform this safely.(59)

⁵ In 2002, the World Health Organization introduced the Focused Antenatal Care (FANC) model which includes four visits with specific interventions for each visit for low- and middle-income countries. In 2016, after reviewing available evidence on the effectiveness of the FANC model, the WHO issued a new recommendation which stipulates that every pregnant woman should have at least eight contacts with healthcare providers with a series of 39 recommendations on the nutritional interventions, maternal and foetal assessments, preventive measures and interventions for physiological symptoms.(31)

The percentage of women receiving PNC from health professionals has also been slowly rising from just 3% in 2000 to 16% in 2016.(49,54) Most women receive their first postnatal check within the first 48 hours after delivery and numbers have been steadily increasing from just 2% in 2000 (49) to 34% in 2019.(50) As with ANC, very few women have additional PNC visits beyond the first 48 hours as recommended. In fact in 2016, less than 2% of women reported postnatal checks between one and six weeks after birth.(54)

2.3.2. Regional variation in service use

Levels of utilization of all three services also vary widely between regions, with highest levels of use usually recorded in the capital, Addis Ababa. As shown in Figure 2.3, in 2019 ANC use (at least one contact) was lowest in Somali region (<30%), higher in Gambella and Tigray regions and highest

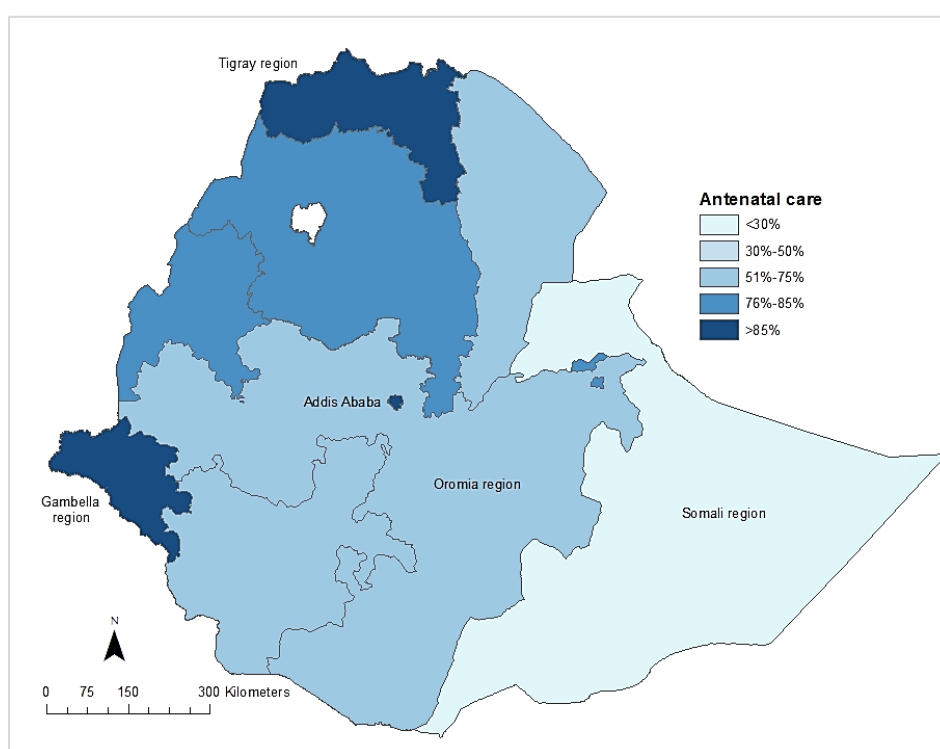


Figure 2.3. Regional variation in ANC use (at least one contact with a skilled provider). Figure created using EDHS 2019 data (50) in ArcGIS Pro (ESRI, Redlands, USA)

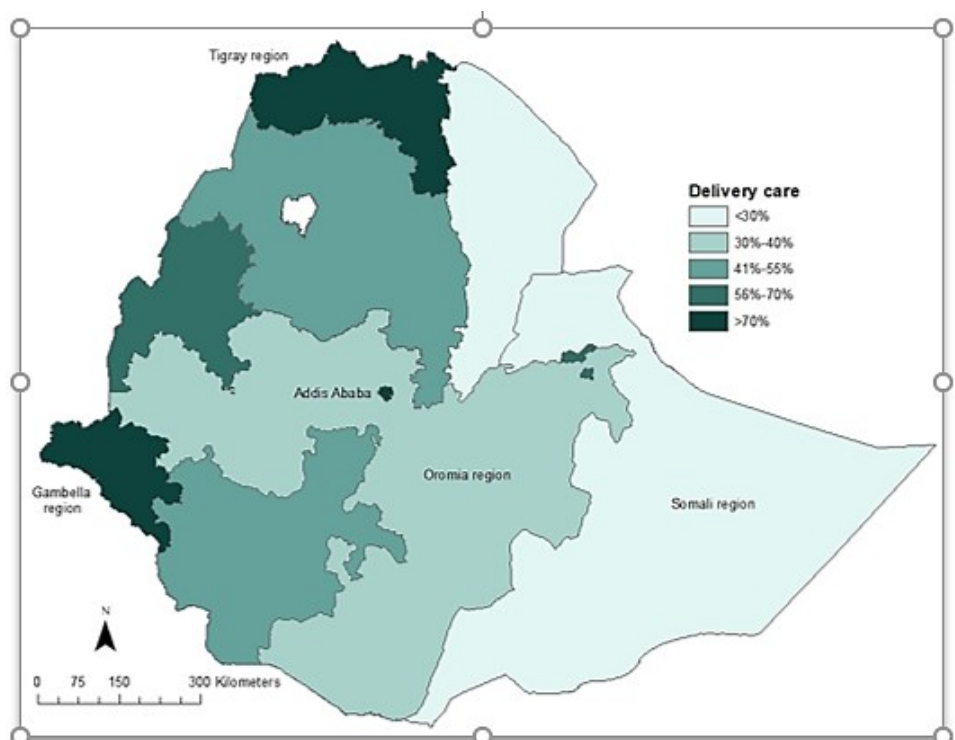


Figure 2.4. Regional variation in delivery care use (proportion of live births in the preceding five years that occurred at a health facility) in Ethiopia. Figure created using EDHS 2019 data (50) in ArcGIS Pro (ESRI, Redlands, USA)

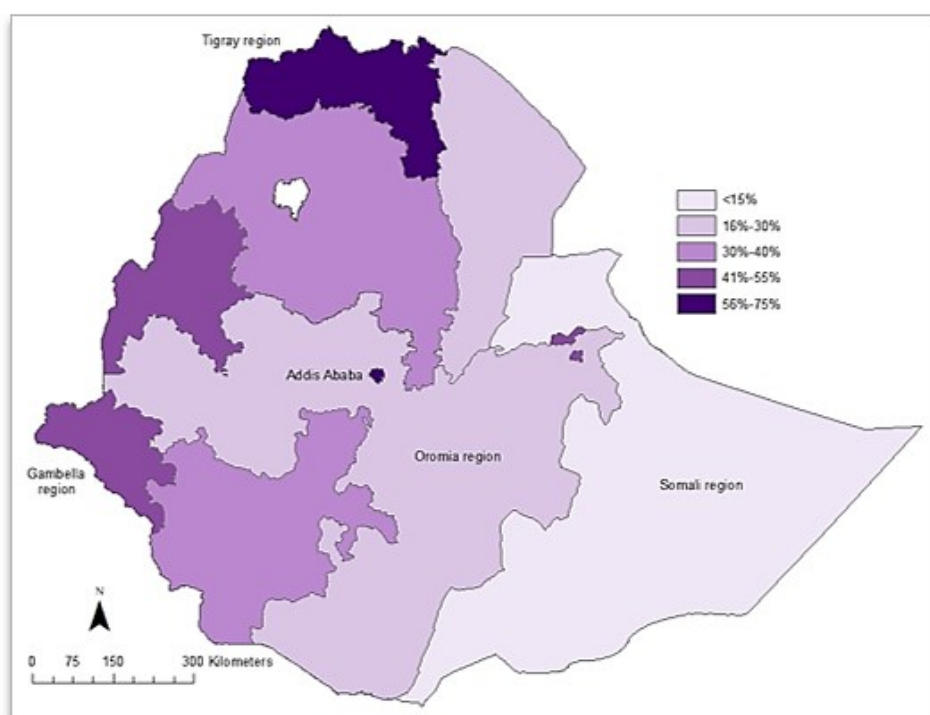


Figure 2.5. Regional variation in PNC use (proportion of women giving birth in the preceding two years that had a postnatal check within the first two days after birth) in Ethiopia. Figure created using EDHS 2019 data (50) in ArcGIS Pro (ESRI, Redlands, USA)

in Addis Ababa (97%).(50) Similar patterns of use were observed for delivery care use (Figure 2.4) and PNC use (Figure 2.5). Somali region generally recorded lowest service utilization while Tigray and Gambella performed at similar levels to Addis Ababa. Therefore, despite improvements in utilization of all services over time, regional disparities persist within the country.

2.3.3. Social gradients in service use

In addition to substantial variation in levels of service use between regions, higher use of services has been noted in urban versus rural populations, among women with higher education levels and those from wealthier households. As shown in Figure 2.6a for ANC use, the absolute differences between urban and rural populations fell sharply after 2014; in 2000, there was a 45% absolute difference in use, but by 2019 this was reduced to 15%. This is an important achievement for Ethiopia where the majority of people are located in rural areas.

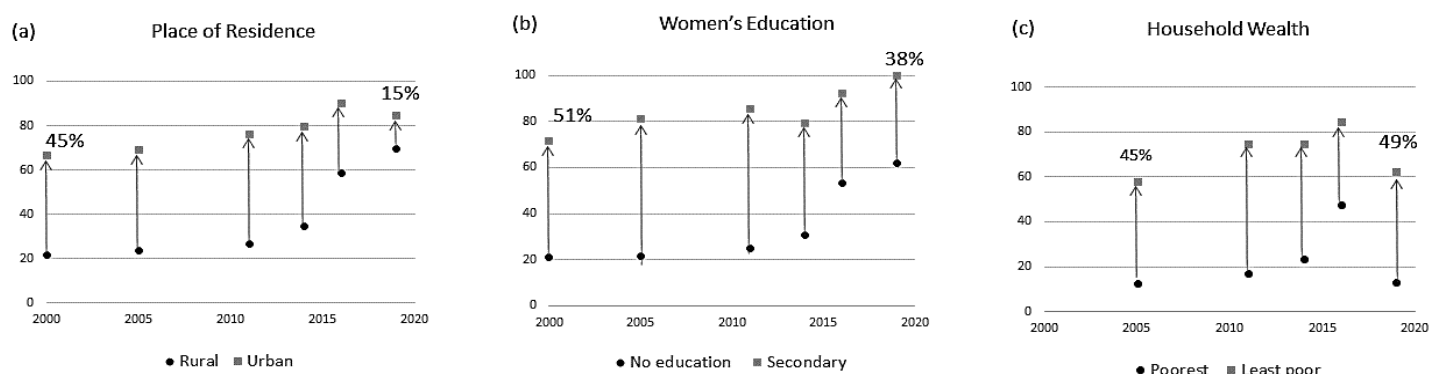


Figure 2.6. Differences in ANC use between 2000 and 2019 by: (a) place of residence (rural vs. urban), (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs. least poor quintiles) in Ethiopia. Figure generated using data from DHS reports.(49–52,54) No data was available for household wealth for year 2000.

The gap in ANC use between women with no education and those with a secondary education also dropped from 51% in 2000 to 38% in 2019 (Figure 2.6b). However, ANC use has roughly exhibited a 40-50% gap between women from the least poor and the poorest households. In addition to sharp divides in levels of use, similar differences in type of provider for ANC have also been reported. Whereas 90% of urban women reported receiving care from a healthcare professional such as a doctor or nurse/midwife in 2016, only 43% of rural women did; when examined by household wealth, 80% of the least poor women had professional care while just 33% of poorest women did.(54)

Absolute differences in delivery care use by place of residence, women's educational attainment and household wealth level are slightly larger than differences observed with ANC use as illustrated in Figure 2.7.

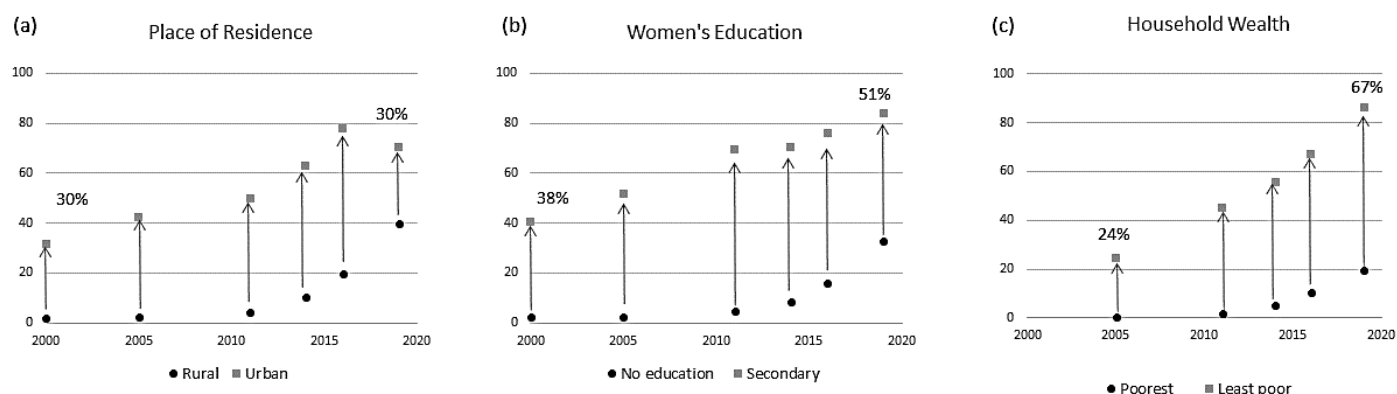


Figure 2.7. Differences in delivery care use between 2000 and 2019 by: (a) place of residence (rural vs. urban) (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs. least poor quintiles) in Ethiopia. Figure generated using data from DHS reports.(49–52,54) No data was available for household wealth for year 2000.

It is concerning to note that household wealth-based gaps in delivery care use seem to be increasing (Figure 2.7c); while in 2005 there was a 24% difference between the poorest and least poor women, in 2019 this was almost 70%.(50,51) With respect to education, the largest disparity was recorded in 2011 at almost 65%; despite a gradual decrease, the difference in delivery care use between women with no education and those with a secondary education was still over 50% in 2019.(50,52)

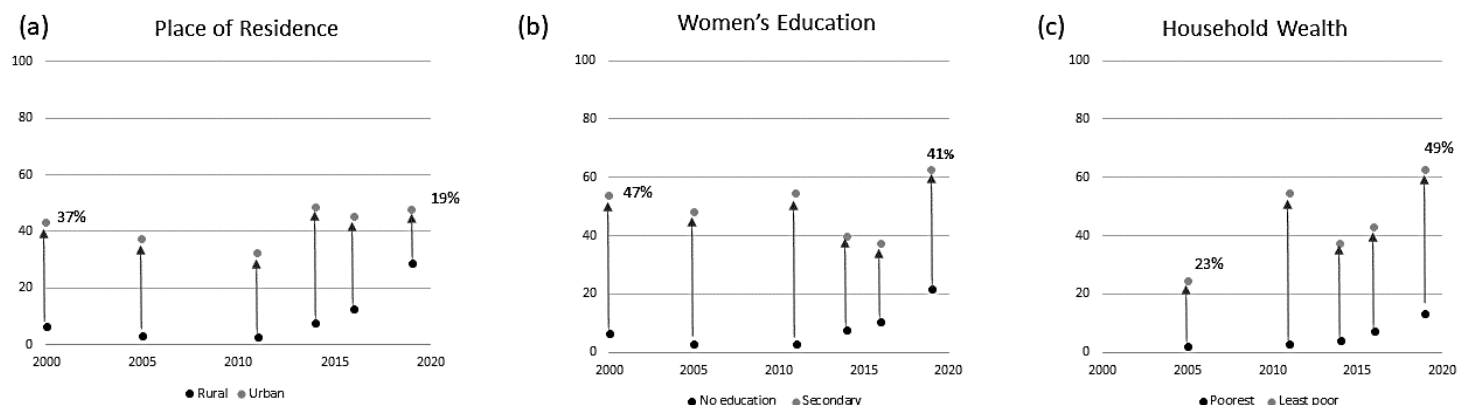


Figure 2.8. Differences in PNC use between 2000 and 2019 by: (a) place of residence (rural vs. urban), (b) women's education level (none vs. secondary) and (c) household wealth (poorest vs. least poor quintiles) in Ethiopia. Figure generated using data from DHS reports.(49–52,54) No data was available for household wealth for year 2000.

Differences in PNC use by place of residence have also been declining since 2000 when there was a 37% between rural and urban women, whereas in 2019 it was 19% (Figure 2.8a). Gaps in utilization levels by women's education level (Figure 2.8b) and household wealth (Figure 2.8c), however, seem to have been fluctuating between 2000 and 2019. Disparities were highest in 2011 (~52% for both) and began to decrease until 2019 when utilization levels began to diverge once again.

The type of provider seen for PNC has also varied over time by place of residence, women's education and household wealth. Smaller proportions of rural women, those with no education and women from the poorest households reported seeing health professionals compared to women urban, educated and less poor women over the past two decades. Differences by education level have, in general, been on the decline since 2005 (40% to 26%), but gaps by household wealth have been widening (22% to 36%).(49–52,54)

2.4. Factors influencing maternal healthcare service use

2.4.1. Antenatal care

2.4.1.1. Low- and middle-income countries

A systematic review of the factors associated with ANC use in Sub-Saharan Africa (SSA) identified 74 observational studies conducted between 2008 and 2018.(60) About one-third of the studies originated in Ethiopia. The majority of studies focused on individual and household-level factors. Higher education levels for both women and their husbands, higher wealth, being employed, lower parity, planned pregnancies, having health insurance, living close to facilities, urban residence and being involved in decisions generally all exhibited favourable associations with ANC use. The review described the association between age and ANC use as context dependent with some studies reporting higher odds of use among older women and others finding higher odds of use among women under 20 years of age.(60) Ownership or use of radio and televisions was also positively correlated with ANC use in a handful of studies. A few studies specifically examined community-level factors.(61,62) For instance, a study from Zimbabwe reported that community-level prevalence of contraceptive use positively correlated with increased odds of ANC use in both urban and rural populations; religious composition of the community and more nurses per capita were significantly associated with higher odds of ANC use among rural women but not urban women.(61)

Another study used DHS data from 32 low- and middle-income countries (LMICs) to explore determinants of the frequency of ANC use to see if they differed from those linked to any ANC use.(63) The authors reported education, age, marital status, household wealth and place of residence (rural or urban) as influencing both use and frequency of antenatal care. With respect to ANC use, education and household wealth showed almost “dose-dependent” associations with ANC attendance with increasing levels correlating with higher odds of use. In terms of frequency of ANC use, women with primary education were likely to have 11% more visits than women with no education (estimate= 0.11, 95% CI: while those with a secondary education were likely to have 37% more visits (estimate=0.37, 95% CI: 0.36 to 0.39). Married women had higher odds of ANC use than unmarried women (adjusted OR=2.5, 95% CI: 2.2 to 2.8) as did employed women compared to unemployed ones (adjusted OR=1.1, 95% CI:

1.05 to 1.13). Women having their first child were most likely to seek ANC compared to women with higher parity while those with unwanted pregnancies had lower odds of ANC use than women who wanted their pregnancy (adjusted OR = 0.76, 95% CI: 0.72 to 0.79). The interaction between urban residence and wealth indicated that the gap in ANC use between urban and rural residents widened as wealth increased. For instance, urban women in the least poor quintile had double the odds of ANC use compared to their rural counterparts (adjusted OR = 2.26, 95% CI: 1.96 to 2.59). The authors also explored differences in the relative influence of factors between countries in Africa, Asia and Latin America, noting consistency in the effects of education, marital status, unwanted pregnancies and, wealth on ANC use across all three continents. The effects of employment varied, exerting a negative effect on frequency of ANC visits in Asia but a positive effect in SSA.(63)

2.4.1.2. Ethiopia

A systematic review focusing on factors associated with women completing at least one ANC visit in Ethiopia included 15 community-based, observational studies conducted between 2002 and 2016.(64) Three studies were carried out in Oromia region (65–67) with one based in Jimma town(67), but none focused on rural areas in Jimma Zone. The authors pooled adjusted estimates for place of residence, education levels of women and their husbands and, whether or not the pregnancy was planned using a random-effects model. Higher odds of having at least one ANC visit were associated with urban residence (pooled odds ratio [OR]=1.92, 95% confidence interval [CI]: 1.35 to 2.72; 8 studies), having some level of education (pooled OR=1.90, 95% CI: 1.52 to 2.37; 13 studies), having a husband with some level of education (pooled OR=1.49, 95%CI: 1.32 to 1.69; 5 studies) and a pregnancy being planned or intentional (pooled OR=2.08, 95%CI: 1.45 to 2.98; 6 studies). Eight studies investigated the association between women's age and ANC use with five indicating that younger women had a higher odds of ANC use (65,68–71) and three studies finding no statistically significant association.(66,72,73) In the review, Tekelab et al. meta-analysed studies that used 20 years as a cut-off for at least one age category and reported a pooled odds ratio of 1.06 (95% CI: 0.53 to 2.15; 5 studies) for women under 20 years compared to older women.(64) Marital status (OR=1.22, 95%CI: 0.78 to 1.91; 5 studies) and parity (OR=1.22, 95% CI: 0.87 to 1.72; 5 studies) were not found to be statistically significant when pooled estimates were generated.(64) Due to differences in the way variables were categorized and reported, the authors reported being unable to generate pooled estimates for occupation, household wealth, women's involvement in decision making, husband's support or approval for ANC, awareness of ANC services and pregnancy-related danger signs. The review authors described mixed findings for these variables.(64)

A few studies identified in the review considered geographical barriers such as travel time (71,74) or estimated distance between household clusters and the nearest health facility (75,76) as

potential factors influencing ANC use. In general, longer travel times or larger distances were associated with lower odds of ANC use. Community level factors, such as norms around ANC or community-level wealth, were not often considered. One study examined several *kebele*-level factors including the *kebele*'s main source of income (farming or mixture of farming and trade), sufficient food production and the average distance between the *kebele* and the nearest health centre.(76) The authors reported living in *kebeles* with mixed income sources rather than relying solely on farming (adjusted OR=1.35, 95% CI: 0.47 to 3.88) and being food secure (adjusted OR= 1.29, 95% CI:0.21 to 8.1) as favouring ANC use.

2.4.2. Delivery care

2.4.2.1. *Low- and middle-income countries*

An analysis of DHS data from 43 countries in Africa and Asia from over 200,000 women identified several factors that significantly correlated with using delivery care.(77) In terms of individual characteristics, higher age, more years of education, not being married and not wanting the pregnancy was associated with increased odds of facility delivery. At household level, wealth, place of residence, sex of household head, having fewer children, husband's age, husband's employment status but not husband's education were important correlates of delivery care use. Living in a community with a high proportion of women using ANC services at least four times as well as using ANC herself was also associated with increased odds of delivery care use. When only African countries were considered, important correlates remained largely similar; however, being unemployed and having husbands with more education were positively associated with delivery care use. Unlike the model including all countries, sex of household head and husband's age did not exhibit statistically significant associations in models with African countries only.(77)

The context-dependent influence of husband's education was also reported in another smaller-scale analysis using DHS data between 2006 and 2010; while in Nigeria women with more educated husbands (secondary versus primary education) had higher odds of delivery care, the opposite was true in Kenya, but no effect was observed in Tanzania.(78) Reported frequency of media use (radio, television and newspaper use combined) also had country-dependent associations; lower use scores were associated with lower odds of facility delivery in Kenya and Nigeria but not Tanzania. (78)

Both papers using DHS datasets were unable to explore the influence of distance on use due to lack of availability of data.(77,78) However, distance is likely to play an important role in women's ability to access delivery care.(79) Indeed, the most commonly reported reasons for not delivering at a health facility reported in Kenya and Tanzania were large distances and lack of transport.(78) A systematic review investigating the relationship between distance and travel time on delivery care use

in SSA identified 57 eligible studies; 30 of these were conducted in Kenya, Ethiopia and Tanzania.(80) No discernible pattern was observed when average distance (n=40 studies) was graphed against mean service use, although a sharp drop was seen after a 40 kilometre threshold was reached. Similarly, when average self-reported travel times were plotted against mean delivery care use, it was difficult to identify a clear trend. However, when ten studies, that had adequate levels of reporting and were appropriately adjusted, were meta-analysed the inhibitory effect of increased distance between home and health facility on delivery care use was apparent (adjusted OR = 0.90, 95% CI: 0.85 to 0.94).(80) The authors concluded that there was evidence that increased distance and travel time were negatively correlated with delivery care use but there was an urgent need to improve reporting. Selection bias was also an issue for 28 included studies either because they sampled easy to reach populations or recruited women using healthcare services.(80)

2.4.2.2. *Ethiopia*

A meta-analysis of factors associated with delivery care use in Ethiopia was recently published. It included 24 observational studies, primarily of cross-sectional design, that were conducted mainly in Amhara and Oromia regions.(81) The authors reported abstracting adjusted effect estimates to generate pooled estimates of association for women's attitudes, women's knowledge, age at first pregnancy, education, parity, occupation, place of residence, availability of information sources, distance, ANC use, place of most recent birth and complications during prior birth with delivery care use.(81) Women with a favourable attitude towards delivery care services, who were younger than 35 years of age at first pregnancy, who were literate or had some level of formal education, lived in urban areas, had used ANC services and had given birth to their previous most recent child at a health facility had higher odds of using delivery care. The authors reported non-statistically significant associations for women's occupation, parity, travel time and prior delivery complications.(81)

Another earlier meta-analysis on factors associated with use of delivery care in Ethiopia reported unadjusted pooled summary estimates using 34 observational studies published between 2000 and 2014.(82) In general, younger age, first-time pregnancies, higher education among women and their husbands, urban residence, better danger sign awareness, ANC use, planned pregnancies and the presence of complications during pregnancy favoured the use of delivery care services among women. There was notable inconsistency in the association of women's involvement in decision-making and use of delivery care, with some studies favouring women's involvement and others not. Different decision-making dimensions were considered by the original studies, which also adjusted for different sets of confounders. Some studies considered women's involvement in decisions about place of delivery (83–85) while others looked at decisions to seek health care in general.(86) One study created a

composite index including women's participation in decisions about healthcare for self, household purchases and visiting friends or family.(87)

2.4.3. Postnatal care

2.4.3.1. *Low- and middle-income countries*

Similar to antenatal and delivery care use, wealth and education demonstrate important associations with PNC use.(88,89) A meta-analysis using data from ten LMICs reported a gradient in PNC use with wealth in which there was a progressive escalation in PNC use with increasing wealth quintiles.(88) Although pooled estimates were not generated because of inconsistent variable classification, qualitative syntheses of studies indicated urban residence, income-generating occupations, shorter distances to facilities and more educated husbands were also associated with increased PNC use.(88) Having fewer children and husbands who are formally employed has also been described to encourage PNC use among women.(89)

An analysis of DHS data from 33 countries in Africa, including Ethiopia, using responses from over 81,000 women examined factors associated with women receiving a postnatal check while at the health facility where they gave birth.(90) In the adjusted model using data available from 25 countries, socio-demographic factors, higher household wealth, urban residence, greater age (up to 45 years, but not over), being unmarried and having a secondary education were favourably associated with receiving a postnatal check. A caesarean-section delivery, being at a public hospital rather than a lower-level facility, receiving care from a doctor versus a midwife, having used antenatal services, longer duration of stay, and having the baby weighed at birth were also associated with receiving PNC.(90) The association observed with education, wealth and ANC use was speculated to be related to better agency among this less-vulnerable, better-informed group of women; better recall and awareness about pre-discharge checks among this group of women may also have factored in to the findings.

2.4.3.2. *Ethiopia*

A systematic review focusing on factors correlated with PNC use in Ethiopia using nine observational studies reported “decision-making”, ANC use, wealth or household income, awareness of danger signs, place of delivery, place of residence and travel time as important factors identified through meta-analysis.(91) Women being involved in decision-making, reporting ANC use, higher income levels, awareness of danger signs, living closer to a health facility, husbands with higher education levels and having delivered at a health facility rather than home seemed to favour women's PNC use. The summary estimate for education level was not statistically significant.

2.4.4. Summary of factors associated with maternal healthcare service use and related research gaps

2.4.4.1. *Potential explanatory factors of service use*

Higher household wealth, higher education levels among women, shorter distances between homes and health facilities and, urban residence were generally associated with increased odds of antenatal, delivery and postnatal care in Ethiopia and across most other LMIC settings.(60,63,64,77,81,82,88–90) ANC use was also positively correlated with both delivery care and PNC use (81,82,90,91); women are also likely to be influenced by past service use, particularly if they had positive experiences.(92)

Among individual factors, positive correlations between danger sign awareness and both delivery and postnatal care have been reported in Ethiopia (82,91); while the role of danger sign awareness on ANC use is unclear, a relationship seems plausible as better awareness of risks and ability to identify problems could contribute to service use. The relationship between women's information sources and service use also needs to be probed further. Associations between media use or ownership and service uptake are assumed to reflect this relationship but may actually be proxies for the influence of household wealth. However, there may be other sources that women more directly rely upon for birth and maternity care specific information such as health workers.

In terms of household/inter-personal factors, women's involvement in decisions about healthcare use is likely to impact service use and needs to be examined using clearly specified constructs. The availability of social support for women to use maternal healthcare services also needs investigation particularly since women rely on family and social networks for assistance with getting to a health facility when they go into labour.(93,94) Qualitative evidence points to the role of birth preparedness and planning in facilitating the use of delivery care.(79,93) In fact, several studies have reported unexpectedly quick deliveries as reasons for women not making it to a health facility(95–99), but some of these home births may be averted with birth preparedness plans in place.

The relationship between health system factors such as contact with community health workers, level of health facility closest to women's homes and quality of care are also important correlates of service use. These need to be considered simultaneously with individual and inter-personal factors to build a more complete picture of influential factors.

2.4.4.2. *Methodological issues with evidence on factors important in the Ethiopian context*

Several systematic reviews summarizing extant evidence on factors that affect women's use of maternal healthcare services are available.(64,81,82,91) However, there are several design, analytic and

reporting issues related to the primary studies included in these reviews that threaten the validity of associations reported. I discuss these here briefly, to demonstrate the need for evidence generated through more rigorous methods, but provide more detailed descriptions of specific issues in Appendices 2.3 to 2.5.

Most primary studies included in the reviews provided inadequate or no information on sampling frames used, participant recruitment processes employed and/or numbers of eligible participants approached. Several studies stated that participants were randomly sampled but provided no details about the sampling design. It is, therefore, difficult to rule out the presence of selection bias, due to the way in which participants are selected or factors that influence participation.(100)

Information bias, which here can result from the misclassification of responses (100), was also a concern. Several primary studies either provided no variable definitions or included insufficient detail making it difficult to know exactly what the reported associations represented. Often, information about how responses were categorized or the reference category used for comparisons was omitted. Additionally, as part of meta-analysis, review authors sometimes combined a wide range of constructs to generate pooled estimates of certain factors that conflated several dimensions making it difficult to disentangle effects. See Appendix 2.4.1 for an example where danger sign awareness and benefits of delivery care use are combined. Some of the pooled estimates were also hard to interpret as they were generated by combining studies that did not always report the same factors. See Appendix 2.3 for an example with level of education completed and literacy.

In several cases, the presence of both overfitting and residual confounding were concerns particularly when statistical significance in bivariable analyses was used to determine what variables were included in multivariable models. This reliance on p-values rather than a conceptual framework or subject-matter knowledge runs the two-fold risk of excluding important confounders as well as incorporating noise variables with spurious associations. Variable selection strategies have also been reported to favour parameter estimates with higher magnitudes and generally produce p-values that are too small since they do not account for multiple testing.(101) Analyses that involve multiple attempts at finding the right combination of variables is described by Harrell as “violating every principle of statistical estimation and hypothesis testing.”(101) Residual confounding in estimates may also be an issue in primary studies where authors chose to model groups of explanatory factors separately rather than as one comprehensive model.

Numerous primary studies also employed a multi-stage sampling scheme which results in clustered data as the first stage of sampling involves selecting clusters such as *kebeles* or health facilities. Responses among cluster members are likely to be correlated thereby violating the assumption

of independence that usually underlies regression models.(102,103) Ignoring clustering may not bias regression coefficients, but standard errors will be underestimated (104) and confidence intervals will appear artificially narrow.(105)

Given the degree of uncertainty around methods employed in the available studies, there is a need to investigate factors that are potentially associated with maternal healthcare use in Ethiopia using more rigorous methods and, then to report the results from such analyses adequately.

2.4.4.3. *Effect of locality on relative importance of explanatory factors of service use*

The consideration of contextual influences on maternal healthcare service has also not been as common in literature originating from Ethiopia as the investigation of individual- and household-level factors has. But, context has been shown to play a role in service use in a few studies in Ethiopia (76,106) and several studies in similar settings (107–109) warranting further exploration. Among the studies from Ethiopia, one from Amhara region found an association between both delivery care and PNC use and living in *kebeles* with mixed income sources rather than sole dependence on farming.(76) Another using nationally representative DHS data reported that communities with a higher than average proportion of women who viewed distance as a barrier and communities with a higher than average proportion of women using ANC services were positively associated with delivering a health facility. (106)

Most of these studies operationalize context at village or primary sampling unit and variables are constructed by aggregating individual responses at these levels. However, to understand how the configuration of influential explanatory factors and their relative magnitude of effect changes with locality requires methods that go beyond incorporating these aggregated variables are needed. This is important in the context of the regional variation in service use that likely translates to differential access at district, *kebele* or neighbourhood levels. Making use of spatial modelling approaches, that accommodate variation in parameter estimates based on location, can provide more insight into how social and geographical contexts affects women's ability to use maternal healthcare services. Conventional regression models generate parameter estimates that represent an effect averaged over the entire study area (global estimates) which can mask what factors truly influence service use in different localities.(110)

2.5. Maternity waiting homes

2.5.1. Purpose of MWHs

Maternity waiting homes (MWHs)⁶ are spaces near health facilities that offer obstetric care that are created to accommodate pregnant women who are within a few weeks of their delivery date. MWHs represent one means to decrease the gap in access levels observed between rural and urban areas; other options include decentralizing care in order to reach all areas and making emergency transport widely available.(111) MWHs can be used to monitor women likely to experience obstetric complications and/or to provide women who experience physically accessibility constraints an alternative to struggling with emergency transport when they go into labour. They have also been used as venues for health education and counselling about pregnancy, childbirth and postnatal care.(111)

2.5.2. MWH models: essential elements

2.5.2.1. *MWH location, infrastructure and services*

To facilitate timely access to obstetric care, MWHs are typically located close to health facilities or on site. How far they are from health facilities is an important consideration (111) and together with their location can affect use.(112) In most cases they exist as standalone structures (113–117) but sometimes rooms within a health facility are designated to function as MWHs. More temporary structures, such as tents, have been used as MWHs in post-conflict settings.(118) Most MWHs are designed as dormitories with several women accommodated within one room.(119–121)

MWHs primarily serve to provide women, and in some cases accompanying family members(114,122,123), with accommodation services. Depending on funding, MWHs may include basic amenities such as beds and bedding (112,116,122,123), kitchens (112,119,122–127) or meal services (128–130) and sanitation facilities such as bathing areas and latrines.(112,114,117,119,123,125–127) However, considerable variability in availability and quality of services has been noted. Some MWHs expect women to sleep on the floor (114,119,131,132), have no kitchens (117) forcing women to cook on open fires (114), lack electricity and clean water (116,131,132) and have dirty latrines.(133) Not all MWHs are also exclusively for pregnant women as they are sometimes used to accommodate family members of patients admitted to the health facility.(114)

⁶ Maternity waiting homes have been referred to by several names including: “antenatal villages”(223), “maternity waiting facility”(162), “maternity waiting room”(150), “antenatal shelter”, “maternity village”, “maternity rest home”, “birthing huts”(111), “house of pregnant women”(224) and “birth waiting homes”(170). For consistency and to avoid adding to an already long list of synonymous terms, these spaces will be referred to as “maternity waiting homes” throughout this thesis in line with the WHO (111) and the majority of peer-reviewed publications.(114,116,124,157,161,175)

Some MWHs also have recreational spaces and offer skill-building (126) or income generating activities (117,123) as well as health education and health promotion sessions to users.(117,123) While most MWH target pregnant women, some accommodate women postnatally as well.(113,134,135) Women do not typically give birth at MWHs (111), although in some settings MWHs provide delivery care as well.(113,127) In general, MWHs accommodate women for free, but some have reported charging a user fee.(123,125)

2.5.2.2. Referral criteria and process

The WHO has listed higher parity, age (extremes of youth or age), short stature, poor obstetric history, malnutrition, anaemia and hypertensive conditions as some of the identifiable factors that elevate the risk of complications and recommends using a combination of distance, socioeconomic and complication risk factors as MWH admission criteria.(111) However, the risk factor selection approach has not been reported to be reliable in predicting which pregnancies will result in complications.(111,136,137) Studies in the 1990's found age and parity to be ineffective complication risk predictors because there was little variation among women experiencing complications; however, a higher proportion of the population would be considered at risk if these predictors were used, which would unnecessarily burden the healthcare system.(137) Risk factors such as history of obstetric complications assessed at antenatal bookings have also been reported to have poor positive predictive value (33%) in some settings.(138) A more recent study examining 10 million births between 2011 and 2013 reported that 29% of births classified as low risk required non-routine obstetric care.(139) The specific MWH admission criteria, therefore, should be selected by countries depending on local priorities and health system capacity. (111)

To ensure that women are appropriately linked to MWHs, they need to be identified and referred during ANC and through community-based mechanisms of the health system.(111) Challenges in reaching women living in remote areas has been noted in some settings (113); in others, the absence of adequate community referral systems has been suggested to lower community awareness and MWH use.(123)

2.5.2.3. User monitoring and transfer for delivery care

In order for MWHs to facilitate women's access to timely obstetric care, users need to be monitored during their antenatal stay and assisted with transfer to the health facility where they go into labour. A few MWHs report providing ANC on site to MWH users (123,128,141), but most expect users to attend routine ANC offered at the health facility. In some Latin American MWHs, labouring women are transported to the delivery room by stretcher, wheelchair or ambulance.(123,134)

In instances where a health facility does not have operative delivery capacity and other essentials to manage complicated deliveries, an ambulance to transfer women to higher level facilities is crucial.(111) However, while some MWHs report the presence of ambulances at the facility to which they are attached, their actual utility may be hindered by lack of fuel (124) or unavailability of drivers. In other cases, one ambulance is shared by several sites which can also compromise timely transfer.

2.5.2.4. Community support

The WHO describes community acceptance and support as influential factors affecting use of and satisfaction with MWHs. There is some evidence that MWHs which are organized and resourced by communities tend to be viewed more positively and are better used.(111,116,121,135)

2.5.3. Recent expansion of MWHs in diverse settings

Historically, maternity homes were mostly used to shelter unwed pregnant women in Europe (142) and North America.(143,144) These homes were mainly run by faith-based organizations and offered both antenatal and postnatal care but delivery care was mostly provided at health facilities.(144) Descriptions of MWHs in Africa, specifically used to house women at risk for delivery complications, have been recorded as early as the 1950s in Eastern Nigeria.(145) Between 1960 and 1990, MWHs were also reported in Uganda, Malawi, Ethiopia, Ghana, Zimbabwe and Egypt.(111,142)

More recently, renewed interest in MWHs has led to their construction in several countries around the world. Starting in 2002, “Mother-Houses” were set up in southwest Cambodia by CARE International; several other provinces also opened MWHs leading to national guidelines being formulated in 2010 to guide expansion.(146) Partners in Health began renovating several MWHs in 2006 in conjunction with the Ministry of Health in Lesotho.(147) MWHs in six provinces in Afghanistan were launched in 2007 in a joint project by UNICEF and the Afghan government.(148) UNICEF also partnered with the local government in the mountainous region of Ningxi Hui in northwest China to refurbish rooms in hospitals to accommodate pregnant women to address regional disparities in maternal mortality.(149) Almost 75% of county-level facilities surveyed in seven provinces in Western China in 2011 had rooms for MWH services while over 90% of county hospitals had these facilities.(150) All rural district hospitals in Zimbabwe had MWHs after the concept was introduced in the 1980s, but most declined into a state of disrepair and were reported to be rarely used.(151) In 2011, twenty MWHs were refurbished and equipped by the Zimbabwean Ministry of Health in partnership with UNFPA using funds from the Japanese Government.(152) Based on the comparison of proportions of maternal deaths between communities with and without the presence of

MWHs⁷(153), scale-up of MWHs began in Liberia with the majority of facilities being constructed by non-governmental organizations.(135) In 2013 in Namibia, several MWHs were introduced under the Programme for Accelerating the Reduction of Maternal and Child Mortal led by the Namibian Ministry of Health and the WHO.(118) Between 2010 and 2013, MWHs were established in the mountainous district of Arghakhanchi in Nepal in response to transport and terrain barriers identified by the community.(154) The same organization also funded three MWHs in West Pokot County, Kenya, in 2011.(155)

While by no means an exhaustive list, these examples highlight the fact that non-governmental organizations are initiating construction or stimulating restoration in partnership with governments to increase the presence of MWHs in impoverished rural settings where women are reported to be experiencing geographical and social barriers to facility-based obstetric care

2.5.4. MWHs in Ethiopia

In Ethiopia, one of the oldest MWHs in the country was established around 1973 at Attat Hospital by a Catholic Mission. Pregnant women were initially accommodated in *tukuls* (traditional huts) largely built by the community, but these were replaced with a cement building with a 48-bed capacity later on.(156)

An inventory of existing MWHs conducted in 2012 identified nine operational MWHs in the country, the majority of which were attached to hospitals and often run by non-governmental bodies. (157) In terms of infrastructure, most MWHs had iron roofs and brick walls, and kitchens and latrines. All except one MWH was described as having access to piped water. Capacity ranged from four beds at Assela Hospital to 44 beds at Hamlin Fistula Hospital. Very few MWHs had a meal service although Attat Hospital was reported to provide food to those who could not afford to bring some. MWH users were generally expected to attend routine ANC at the health facilities and were not provided any assistance with transfer to the delivery room when they went into labour.(157) Attat and Gidole Hospitals had well-established community outreach programs and a steady flow of users.

In 2015, the Federal Ministry of Health released guidelines for establishing MWHs in Ethiopia in anticipation of national MWH service expansion.(158) The guideline outlines requirements around admission criteria, accommodation facilities and health services in relation to MWHs. It also delineates responsibilities that need to be assumed by all levels of government from the Federal Ministry to the

⁷ A mid-cohort analysis was conducted to compare whether the proportion of maternal deaths was different between communities with MWHs present (n=3 deaths out of 8,477 child bearing women) and those without (n=12 deaths out of 9,567 child bearing women) using a Wald test (Wald $\chi^2=4.22$, df=1, p=0.040).(153)

kebele administration.(158) The Ethiopia National Reproductive Health Strategy includes a performance target in which 75% of health centres in the country are required to have MWHs by 2020.(159) MWHs are also endorsed as a strategy in Ethiopia by UNFPA which stated that they “are effective interventions in increasing utilization of maternal healthcare services...and improving birth outcomes particularly among hard to reach rural-dwelling mothers”.(160)

A national survey conducted in 2016 reported over 50% of health facilities (n=2,001) offered MWH services with all regions apart from Gambella having MWHs. The majority were described to be providing food to users as well as health education. Most MWHs were located at health centre level (97%) and in rural areas (64%). Almost all MWHs received community contributions (82%) in the form of food, furniture and construction materials. About 55% of health centres had one room but one-fifth had at least three rooms. While the average maximum MWH capacity at health centre level was seven, on average only about two users were registered during the survey visits.(19) Photographs of MWHs within our study districts are included in Appendix 2.6 to illustrate the status of existing amenities.

2.5.5. Existing evidence on effect of MWHs

In general, evidence on the effect of MWHs on use of delivery care, maternal mortality, maternal morbidity as well as perinatal mortality has been described to be of “very low quality”.(140) A scoping review on the effect of MWHs on newborn outcomes reported that there was insufficient evidence to make definitive conclusions about the impact of MWHs.(161) To date, no randomized, controlled trials evaluating the effect of MWHs on health and mortality outcomes exist.(162) The WHO, therefore, only conditionally recommends MWHs.(140) A detailed summary of correlations between MWHs and mortality and health outcomes is provided in Appendix 2.7 while an in-depth critique of a meta-analysis on the effect of MWHs and perinatal mortality in Ethiopia is included in Appendix 2.8.

2.5.5.1. *Correlations with maternal healthcare service use*

The link between the presence of MWHs and changes in facility deliveries was examined by observational studies from Eritrea (124), Kenya (163), Zambia (164–166) and Zimbabwe (167), Guatemala (127), Nicaragua (128) and Timor Leste. (113) The majority of studies pointed to favourable correlations. Three studies compared the percentage of facility deliveries before and after the introduction of MWHs without any adjustment for confounders or any data specifically linking MWH use to delivery site. In Eritrea, an increase in the absolute number of facility deliveries at 11 facilities was reported when data were graphically examined 12 months prior to MWH introduction compared to 20 months after.(124) An increase in the percentage of deliveries over one year in Samburu county (Kenya) was noted after the construction of an MWH.(163) In Timor Leste no statistically significant

difference in facility deliveries (stratified by distance to health facility) was found after the introduction of MWHs in two districts as compared to levels before.(113)

Two studies adjusted for the presence of confounders using multivariable models to look at associations between MWH use and place of delivery. In Zimbabwe, MWH users had a significantly higher odds of hospital delivery compared to clinic or home deliveries than non-users after adjusting for age, parity, husband's employment status, wealth, pregnancy complications and the use of traditional care methods.(167)

More recently, researchers in Zambia reported home delivery to be less likely among MWH users than non-users (165); earlier formative research in two of the seven study districts indicated that facilities with MWHs had a higher odds of facility delivery than those without.(164) It is interesting to note, though, that the mean proportion of facility deliveries at two intervention sites examined six months before and 14 months after introduction of the upgraded MWHs did not change despite significant improvements in quality scores and higher MWH utilization at both sites compared to three comparison sites.(114) The same group reported statistically significant associations between MWH use during the woman's most recent delivery and attending at least four ANC visits during most the most recent pregnancy as well as attending all PNC visits during the most recent pregnancy in early 2016, presumably prior to upgrading MWHs.(168) A table with a summary of study details is provided in Appendix 2.9.

2.5.6. Factors influencing actual use of MWHs

A series of factors potentially affecting utilization of MWHs have been identified mainly by qualitative studies soliciting diverse perspectives including that of community health workers, health professionals and community members.(112,116,169–174,119,123,128,131–134,157) Several quantitative studies examining correlations between various factors and MWH use or comparing characteristics between MWH users and non-users also exist.(125,126,175–178) Most of the findings stem from studies conducted in SSA, but include a few studies from South America and Asia⁸.

There have been mixed findings with respect to the association between age or parity and MWH use. While a study in Ethiopia reported younger women were more likely to use MWHs than women over 35 years (178), a Zambian study found not statistically significant association.(126) Similarly, in two studies a higher proportion of MWH users were either first-time mothers or women with just one

⁸Countries in Sub-Saharan Africa include those in Eastern (Ethiopia, Kenya, Tanzania, Malawi), Southern (Zambia) and Western (Ghana, Liberia, Sierra Leone) regions. Countries outside Africa include Nicaragua and Guatemala in the South American continent, and Indonesia, Nepal and Laos in Asia.

child (175,177), but one study found no significant correlation with parity.(126) A qualitative study conducted with about 30 health facility users in Zambia uncovered an interesting link between age, decision-makers and complication risks. Husbands of younger and nulliparous women generally had the final say on whether or not their wives stayed at MWHs. They took advice from ANC nurses regarding complication risks into consideration. Older women made their own decisions and often felt they were familiar enough with the birthing process to go to a facility when they were in labour rather than stay at MWHs. On the contrary, some younger women felt uncertain about when to go to an MWH and generally stayed at home until it became obvious that they were in labour.(131)

In Ethiopia, husbands were noted to be instrumental in providing practical support to MWH users. Almost half of the women who used an MWH in an Ethiopian study made the decision to come jointly with their husbands.(172) Other family members may also be involved in decision-making around MWH use; 46% of MWH users in a Malawian study described being strongly encouraged by their mothers or mothers-in-law to stay the MWH.(177) Having a higher sense of self-esteem and learning how to negotiate with principal decision-makers enabled Indigenous women to use MWHs in Guatemala.(134) This was important in this context as men had reservations about their wives staying at MWHs; their recalcitrance was in connection with transport costs and disruptions to household management associated with MWH stay.(134) Anxiety around leaving children at home, particularly younger ones, may also influence MWH use.(131,170,174,179) Knowing that they can count on their social networks to provide care for children in their absence represents an important facilitator of MWH use for women.(131,156,172) Conversely, having husbands who are unwilling or unable to look after children hinders MWH use.(128)

Higher levels of household wealth have generally reported to be associated with lower levels of MWH use, although indicators used for wealth vary quite a bit potentially affecting results. In Ethiopia, the authors relied on women's rating of their wealth status in relation to their neighbours (175) while in Malawi whether or not households had a toilet in their home was used as a proxy for wealth.(177) In Tanzania, an asset-based wealth index was created and women from households in the first four quintiles were compared against those in the least poor quintile; higher odds of MWH use was linked to belonging to lower wealth quintiles.(125) In Ethiopia, a higher proportion MWH users than non-users were of the opinion that financial barriers created delays in securing transport to reach health facilities.(178) However, qualitative studies in Ethiopia indicate that one of the concerns with MWH stay is the potential loss of income through women's absence.(131,172,179) The burden of indirect costs associated with MWH stay are also experienced more acutely by poorer families (170) and in some cases makes husbands less supportive of MWH use.(131) There is a need, therefore, to determine what effect wealth has on MWH use in rural Ethiopia using reliable measures of household wealth.

Qualitative studies largely indicate that higher awareness among women and the community about MWHs, available services and their function supports use, whereas a lack of awareness leads to poor use.(119,128,172) Women who have accessed maternal health care services or been engaged by community health workers are likely to be more aware about MWHs.(179) However, assessments of the level of community awareness about MWHs sometimes differs depending on the stakeholder perspective being evaluated; in Ethiopia, while health workers and HEWs felt the community was generally well-informed about MWHs, non-users explained that they were not told about MWHs and rather, were advised to come to the health centre when they experienced labour pains.(174)

Education, as assessed through women's self-reported level of schooling completed, was generally not reported to be significantly different between MWH users and non-users.(125,126,177) However, two studies were health facility-based (125,130,177) and, therefore, likely looked at women who successfully managed to overcome barriers typically associated with access to care. In Nepal, discussions with community members revealed the perception that uneducated women are likely to be more vulnerable to pregnancy problems and could benefit from MWH stay.(119)

While none of the available studies examined the association between danger sign awareness and MWH use, one study found a higher odds of MWH use among women who had been informed that they may be at risk for complications.(177) However, no significant association was found between having complications during pregnancy, such as hypertension, and MWH use.(178) Qualitative evidence suggests that fear of complications (131,156) or experiencing them in the past (131,170) could be important motivators for both delivering at facilities and staying at MWHs; in fact, some community members in an Ethiopian study perceived MWHs as places for women with complications to stay at, which could influence who uses them.(174) Women attending under-five children's clinics explained that complication risk susceptibility is also sometimes influenced by age; younger women are more fearful of delivery complications as they are sometimes told they "would not be able to push the baby out", whereas older women were felt more likely to "bleed a lot after giving birth".(131)

Three studies reported higher MWH use among women who lived further away from a health facility than closer to it.(125,126,178) Each study evaluated physical separation differently, using a wide range of distances or estimated travel time in the process. In Tanzania, for instance, women living more than 50km away from the hospital had higher odds of MWH use than those living within five kilometres.(125) In Zambia, MWH use was higher among women located 15-24 kilometres (from village centroid to MWH) compared to those less than ten kilometres.(126) Travel times greater than 30 minutes were linked with elevated MWH use in Ethiopia.(178) However, in Malawi, the average distance between MWH and homes was found to be lower among users than non-users; however, no information was provided about how this was ascertained.(130) The relationship between MWH use

and distance, thus, may be context dependent. In Ethiopia, qualitative evidence highlights the importance of proximity to social support from home when MWHs do not provide food.(179) Moreover, physical access barriers that often hinder facility delivery present similar obstacles to MWH stay among women living in remote areas with poor road networks and limited access to transport options.(116,131,170,174) In Zambia, women interviewed at health centres explained that those that live close to health facilities do not need MWHs; but they may be of benefit to women living far away. For those women, it was expected to provide the option to head to a health facility at their convenience rather than under the pressure of labour. It was explained that even those who may not have access to transport could walk to MWHs, which would be difficult once labour began.(131) In the same study, women from catchment areas without MWHs all felt that they would be useful to have, despite acknowledging that many women who do not use MWHs in areas where they are available cannot do so because of transport constraints.(131) Another qualitative study in Zambia highlighted women's challenges in returning home after delivery with a newborn baby in addition to belongings carried for MWH stay; one woman described this as an impossible feat to accomplish on the bicycle her husband borrowed from their neighbours.(116)

How MWHs are used also moderates the influence of distance. Women who present at the very early stages of labour are often asked to wait at MWHs rather than being sent back home(123,129), irrespective of distance. The health facility level to which an MWH is attached may be another factor shaping the influence of distance on MWH use. In a Nicaraguan study, a possible reason for the underuse of MWHs by women living far away was that they were located at health centre level. However, women living more than six hours away were more likely to go to a hospital to give birth, as facilities at this level were perceived to be better at handling complications than lower level facilities.(128) An expectation that ambulances will transport women in labour to a health facility contributes to the reluctance to use MWHs to a certain extent.(170,174) The inability of families to bear costs associated with transport can also reduce the likelihood of MWH use, particularly when transport costs increase with distance to MWH.(123,128,157,169,179)

Qualitative studies have uncovered that the uncertainty around expected delivery dates makes knowing when to go to an MWH challenging for some women.(169,179) Moreover, there is an implicit assumption associated with the promotion of MWH as solutions to physical access issues, that pregnant women are able to organize and afford transport as well as make arrangements for their absence ahead of time. In fact, stakeholders interviewed in Sierra Leone stated barriers to MWH stay are not insurmountable if families engage in better planning.(170) However, hardly any studies investigated if or how MWHs are incorporated into the process of planning for births, and, what challenges may still remain even if families plan to stay at MWHs.

MWH use is also intimately linked to perceptions, prior experiences and requirements associated with delivery care.(116,122,123,131–133,169,170) Women who were dissatisfied with health facilities and health workers or whose needs were not met may be less inclined to use MWHs.(119,128,169,171,174) The converse is also true; for instance, Attat Hospital in Ethiopia, which has the oldest MWH in the country, has a well-established relationship with the community that trusts it will be able to access reliable care at the hospital which key informants stated is an important driver of MWH use.(156,157) In Guatemala, users described receiving patient-centred care and feeling valued which encouraged other women to use the MWH services.(134) User experiences have also been described to have a ripple effect on use with positive experiences of past MWH users encouraging more women to use these facilities.(156,157) The opinions of community and facility health workers also affect referral levels and, therefore, use. (174,179)

The quality of accommodation and support services available at MWHs have been widely discussed as important elements potentially affecting utilization. (114,116,162,169,172,174,180,119,123,128,129,132,133,156,157) One of the most frequently mentioned challenges faced by women is related to availability of food. In MWHs where meals are not provided, women who do not have family who can bring them food, or live too far for family to provide this support, or who come from families which simply cannot afford this added cost of stay, find it hard to use MWHs.(119,122,123,128,132,157,170,172,174) Sometimes due to the uncertainty attached with duration of stay, women run out of the food they brought with them.(131,180) MWH users are also not always satisfied with the quality and variety of meals when they are provided.(157,169,172,174) In some cases, women are willing to prepare their own meals but kitchens are in poor condition, too far from the MWH or have no cooking implements.(116,119,132,172,174) Despite the need and desire for companions to stay with users, many MWHs neither have space for, nor provide food to, companions.(116,123,131,174) Other areas where MWHs have been found to be lacking include inadequate numbers or complete absence of beds and bedding, no clean water or electricity/lighting, no clean bathing areas and toilets, no secure storage spaces and/or privacy.(116,119,126,129,131–133,169,180) Where improved facilities are available, higher satisfaction has been recorded. In Malawi, for example, women were more satisfied with a custom-built MWH with private rooms compared to a standard, dormitory style MWH; the bespoke MWH design had higher safety, sanitation, storage, companion space and building maintenance ratings from women that were all associated with satisfaction levels.(117)

It has been observed that MWHs affiliated with non-governmental organizations offer better quality amenities and services than public MWHs (116,123,131), which are often more poorly or inconsistently funded. A before-and-after analysis of monthly utilization levels at five sites (two intervention, three comparison) reported a statistically significant change in use at a faith-based MWH

but not a public MWH, although both received infrastructure, supply and equipment improvements outlined in the intervention model⁹.(114) However, the effect of quality on MWH use may be context dependent as a survey of over 100 MWHs in Liberia reported community-funded MWHs registered higher use levels compared to NGO-funded MWHs.(135)

In terms of quality of support services, the lack of monitoring of MWH users by health workers and the minimal level of assistance in transferring to the labour ward serve to negate the anticipated benefits of MWH stay. Several studies highlight women's disappointment with the neglect by health workers experienced during their stay and call for better monitoring and care.(119,129,131–133,157,172) Women in Zambia who had used public MWHs went so far as to say they were a waste of time and did not reduce risks because they could spend weeks there without any visits from midwives.(131) While the opportunity MWHs offer for rest is appreciated (133,180), some women complain about the lack of activities to keep them occupied (129,169) and the loneliness and boredom they experience, particularly in less-used MWHs or where companions are not permitted.(123,132,180) Likewise, MWHs with televisions, health information sessions, skill building classes and gardens are viewed more positively by users; the opportunity to socialize with other pregnant women is also valued.(171,172) Older women in Zambia felt that being idle delayed the onset of labour and preferred to carry on with their routine at home than rest at MWHs.(131)

Focus group discussions with stakeholders of a failed MWH in Ghana exposed the fact that establishing the home near a mortuary, at a fair distance from the hospital, and without staff, made women uncomfortable and contributed to very poor use.(112) The fact that MWHs are not always exclusively used by pregnant women has also been a source of concern for some.(119,126,133)

2.5.7. Factors associated with intention or willingness to use MWHs

Five studies, mostly from Ethiopia, have reported on factors linked to intended use or women's willingness to use MWHs rather than actual use.(181–185) Correlations have been reported between intention or willingness to use MWHs and: woman's education level and that of her husband (184), danger sign awareness (184), anticipated complication risks (181,183), prior delivery care use (183,184), history of delivery complications (184), sole decision-making by the woman (185), certainty about finding a companion (183,184), confidence in receiving help with childcare (183,184), feeling MWH stay will be supported/approved by husband and family (183–185), higher household wealth

⁹ The Core MWH Model was described to include 3 main components, two of which were evaluated in the study by Bonawitz et al (2019): (i) infrastructure/supplies/equipment involved the construction of cement structures with a lighting source, lockable doors and windows, a cooking space with utensils, bathing and laundry areas, beds with bedding and mosquito nets, access to clean water and a lockable storage room; and (ii) health system linkage which ensured MWH users were monitored by health workers at the facility to which the MWH was attached to.

(184,185), feeling it is possible for companion to be away from work (184), finding transport and food costs associated with MWH stay affordable (184), having used antenatal care (185) and confidence that health workers will be available.(183) Concerns about availability of food (180,185), fears around being alone at night (185) can also influence intention to stay at MWHs.

2.5.8. Summary of factors associated with MWH use and associated research gaps

While only a handful of studies that quantitatively investigate factors associated with MWH use are available¹⁰(125,126,177,178,183), several qualitative works provide insight into the complexity and interconnectedness of influences affecting use.(82,116,123,129,131,133,170,172,179)

In general, increased physical separation between homes and MWHs, quantified either in terms of distance (125,126) or travel time (178), has reported to be positively correlated with MWH use. However, qualitative studies exploring barriers to MWH use suggest limited access to transport and reliable road networks still act as obstacles for women in remote areas.(82,116,131,170) The need to be close enough to social networks to receive food supplies during MWH stay also moderates the relationship between distance and MWH use in Ethiopia.(179) How physical separation affects MWH stay, therefore, needs to be quantified in the rural Ethiopian context.

There is evidence that household wealth levels affects MWH use, with some studies indicating that women from poorer families being more inclined to use MWHs.(125,177) However, given the diversity in indicators used to represent wealth, including subjective ratings of wealth levels (175) and whether or not toilets are located inside homes (177), the question around the role of wealth in MWH use in Ethiopian remains largely unanswered. Concerns voiced by families about potential loss of income during women's stay at MWHs (131,172,179) and the disproportionately high financial burden of indirect costs on poor families (170) underscores the need for further investigation.

Inter-personal influences, such as availability of social support and decision-making patterns, have also been qualitatively identified as instrumental in MWH use. Associations between MWH use and younger age (178), lower parity (177) or being married (126), that are statistically significant in some cases but not others, may become relevant depending on who the decision makers are.(131) While involvement in decision making has been alluded to be important for intended MWH use (185), it has not been evaluated in relation to actual use. Similarly, the pivotal function of social networks in

¹⁰ This pertains to peer-reviewed literature published as of August 2020 with the following terms included either in the title or abstract: (("antenatal" OR "matern*" OR "birth*") AND ("waiting") AND ("village*" OR "room*" OR "hut" OR "home*" OR "area*" OR "facility*")) OR ("antenatal shelter" OR "maternity village" OR "maternity rest home" OR "house of pregnant women")

facilitating access to, and supporting stay at MWHs has been repeatedly described qualitatively (82,128,131,170,179), though not assessed quantitatively.

The influence of women's occupations on MWH use has not been studied in the rural Ethiopian context. Women with income-generating occupations may have the agency, fewer children and/or financial independence to use MWHs. On the other hand, they may have less time to stay at MWHs than housewives; this needs to be investigated.

There was a distinct absence of community-level factors among factors investigated by studies on MWH use. Given the link between experiences with, and perceptions of delivery care (116,122,123,131–133,169,170), it is plausible that how disposed the community is towards delivery care could affect women's willingness and ability to use MWHs. Additionally, impressions about maternal healthcare services, including MWHs, have been described to spread by word of mouth in low-resource settings (122,123) and can impact use.(156,157) Finally, health system factors such as levels of community engagement to promote awareness of MWHs (119,128,172), the quality of both delivery care (82,119,128,169) and MWH services (82,114,169,172,180,116,123,128,129,132,156,157,162) and referral mechanisms in place to link women to MWHs may also be important in determining whether or not MWHs are used by women.

2.6. Role of community and religious leaders in maternal healthcare service use¹¹

2.6.1. Community leaders

Leaders can be regarded as individuals who “control or manage other people because of their ability or position”.(186) Community leadership goes beyond influencing others, as community leaders are expected to act as local change agents who identify community needs and advance their interests.(187) Norms of reciprocity and trust are central features of communities (188) which community leaders leverage to effect positive change. In Ethiopia, HEWs have been described as one important subset of community leaders. Like community health workers in other settings, they link communities to health systems through their roles in service provision, cultural brokerage and as agents for social change.(189) As described in Section 2.1.3, HEWs work closely with other community leaders, such as members of the WDA, and have been described to be the cadre with the most frequent interaction with other leaders in the health sphere; this increased interaction is partially influenced by a

¹¹ A brief description of the role of community and religious leaders is provided here as context to the local leader intervention component that was evaluated as part of this thesis. An in-depth exploration of these groups and the intervention component is out of the scope of this thesis as it forms a core part of the research being conducted by other doctoral students on the research team.

high level of trust in them.(190) They are also trusted by the community, which often plays a role in their selection.(191)

The WDA is designed to be the embodiment of participatory engagement as it confers leadership roles to one woman from every five households.(22) These are voluntary positions are held by women in model families who are charged with the responsibility of disseminating health information and promoting health service use within their network of five households.(192) Positive associations between the density of these networks and antenatal and delivery care use have been reported in Ethiopia.(26) Similarly, correlations were found between HEW outreach activities and increased odds of ANC and PNC use and birth preparedness planning but not delivery care service use (193), which may have been modulated by distance of the networks from health facilities.(194) However, another study reported positive associations between home visits by HEWs and the use of all three maternal healthcare services (195); this may be a reflection of the heterogeneity in local implementation. At the national level, a link between the introduction of the health extension and WDA initiatives and sharp declines in maternal mortality levels between 2003 and 2016 has been reported.(196)

The potential of community health workers, such as HEWs, to realise equitable behaviour change in LMIC settings has also been previously described.(197) One way in which this may be achieved is by gradually effacing community norms that make it more difficult for groups marginalized by factors such as wealth to access maternal healthcare services. However, community health worker action has limited effectiveness in counteracting the negative impact of key structural barriers to access such as poor infrastructure, or poverty.(197) Additionally, there is a need to invest in capacity building of community health workers and better support them materially in order to facilitate the role that they play in empowering communities.(198)

2.6.2. Religious leaders

Religion is often mentioned as a factor correlated with use of maternal healthcare services.(60,93,199,200) Whether the observed associations are directly attributable to religious values or associated with other factors is not entirely clear. Religion is difficult to measure and pathways of influence even harder to investigate.(201,202) A synthesis of qualitative studies in North American settings summarized potential mechanisms through which religion may influence differences in healthcare access; some examples include interpretations of health based on theological understanding and perceived discrimination due to religious values.(203)

Some studies speculate that the link between religion and belief in the supernatural is related to fatalistic views that are sometimes adopted; this can impact health-seeking, willingness for screening, acceptance of treatment related to various health conditions and can dampen family willingness to support care.(203–209) Regardless of the mechanism through which religion may nor may not impact maternal healthcare service use, religious leaders and faith-based organizations are recognized influential and often engaged to improve access to care.(210–214)

Religious leaders are commonly integrated into interventions addressing health-related issues that intersect with religious values such as female genital mutilation (215), condom use (216) or HIV testing.(212) In Ethiopia, for example, the acceptability of using religious leaders to provide psychosocial support to HIV-infected individuals was investigated as HIV is sometimes viewed as a “punishment from God”.(212) The most extensively researched health intervention in the context of religion and religious leaders, though, is contraceptive use.(217,218) Qualitative evidence suggests that depending on the individual’s interpretation of their faith, having many children can viewed as a duty by some, while others feel that it is their moral responsibility to limit the number of children in order to provide the best possible care for their children.(219) These beliefs can affect decisions around contraceptive use or birth spacing and religious leaders have been found to be useful in guiding choices. For instance, in Nigeria a significant increase in contraceptive uptake among women was reported when religious leaders were used to sensitize families about the importance of family planning.(210)

Religious leaders, who are most often male, have also been targeted by interventions aiming to catalyse male involvement in reproductive and maternal health.(217) In some cases, they have also been used to urge women to use maternal healthcare services. For example, religious leaders in Tanzania were trained to be safe motherhood promoters, encouraging the use of delivery care services through home visits and sermons during worship services.(220) While there do not seem to be many interventions in rural Ethiopia that make use of religious leaders to help make motherhood safer, formative studies in the study area confirmed that religious leaders regard promoting maternal healthcare service utilization as one of their duties. This is in addition to providing emotional support and encouraging the community to work together to assist labouring women get to health facilities.(221)

2.7. Chapter summary

In this chapter I described the development of the healthcare system in Ethiopia where primary healthcare is firmly rooted and pervasive community health structures exist that can be leveraged to promote equitable maternal healthcare service use and contribute to improving health equity. While Ethiopia has made impressive progress in uptake of maternal healthcare services, large regional variation and disparities along social gradients, particularly household wealth, persist at concerning

levels. I show that individual and household-level influences of service use are widely reported, but there is a need to improve the methodological rigour through which evidence is generated. Furthermore, given the large regional and social-determinant based disparities in use, contextual differences in the experience of barriers that may be partially driving these differences need to be explored appropriately.

I then introduced MWHs and discussed their proliferation in Ethiopia, to address geographical barriers preventing uptake of delivery care in rural areas, despite the lack of conclusive evidence on their effectiveness. MWHs generally provide low quality accommodation and services to pregnant users, which could be impacting use. However, there is a need to understand what other factors affect use of MWHs located at health centre-level in rural Ethiopia. While quality improvements are needed, it is unlikely that they will be sufficient to improve use as women likely face social barriers as well.

In the next chapter, I outline the methods used to identify determinants of MWH use, explore spatial variation in factors affecting antenatal, delivery and postnatal care use, and evaluate how effective upgraded MWHs and local religious and community leader-training is in improving delivery care use in a rural Ethiopia setting.

2.8. Chapter References

1. Kloos H. Primary health care in Ethiopia under three political systems: community participation in a war-torn society. *Soc Sci Med.* 1998;46:505–22.
2. United Nations. Country Profile: Ethiopia [Internet]. 2015 [cited 2020 Oct 9]. Available from: https://data.un.org/CountryProfile.aspx/_Images/CountryProfile.aspx?crName=Ethiopia
3. Keller EJ. Drought, war and the politics of famine in Ethiopia and Eritrea. *J Mod Afr Stud.* 1992;30(4):609–24.
4. Weis J. Women and Childbirth in Haile Selassie's Ethiopia. University of Oxford; 2015.
5. Vaughan S. Revolutionary democratic state-building: party, state and people in the EPRDF's Ethiopia. *J East African Stud.* 2011;5(4):619–40.
6. Slikkerveer LJ. Rural health development in Ethiopia. Problems of utilization of traditional healers. *Soc Sci Med.* 1982;16:1859–72.
7. Milkias P. Zemecha-an assessment of political and social foundations of mass education in Ethiopia. *Northeast Afr Stud.* 1980;2:19–30.
8. Clapham C. State, Society and Political Institutions in Revolutionary Ethiopia. *Inst Dev Stud Bull.* 1990;21(4):35–45.
9. Wamai RG. Reviewing Ethiopia's Health System Development. *JMAJ.* 2009;52(4):279–86.
10. Health Policy of the Transitional Government of Ethiopia. Addis Ababa; 1993.
11. El-Saharty S, Kebede S, Dubusho PO, Banafsheh S. Ethiopia: Improving Health Service Delivery. Washington, DC; 2009.
12. Alebachew A, Waddington C. Improving Health System Efficiency. Ethiopia Human resources for health reforms. Geneva, Switzerland; 2015.
13. World Health Organization. Establishing and monitoring benchmarks for human resources for health: the workforce density approach. Spotlight on health workforce statistics. 2008.
14. World Health Organization. Health workforce requirements for universal health coverage and sustainable development goals. Geneva, Switzerland; 2016. (Global Strategy on Human Resources for Health).
15. Ethiopian Federal Ministry of Health. Health Sector Transformation Plan. Addis Ababa; 2015.
16. Pearson L, Gandhi M, Admasu K, Keyes EB. User fees and maternity services in Ethiopia. *Int J Gynaecol Obstet.* 2011;115:310–5.
17. Ethiopian Public Health Institute. Ethiopia Service Provision Assessment Plus Survey. Addis Ababa; 2014.
18. Brown AT, O'Neill OM, Yoon KY. Cluster coordination in a government-led emergency response in Ethiopia [Internet]. Field Exchange (blog) Emergency Nutrition Network. [cited 2020 Oct 9]. Available from: <https://www.enonline.net/fex/56/clustercoordinationethiopia>
19. Ministry of Health, Columbia University, Ethiopian Public Health Institute. Ethiopian emergency obstetric and newborn care (EmONC) assessment. Addis Ababa & New York; 2017.
20. Abraham O, Linnander E, Mohammed H, Fetene N, Bradley E. A Patient-Centered Understanding of the Referral System in Ethiopian Primary Health Care Units. *PLoS One.* 2015;10(10):e0139024.
21. Cometto G, Ford N, Pfaffman-Zambruni J, Akl EA, Lehmann U, McPake B, et al. Health policy and system support to optimise community health worker programmes: an abridged WHO guideline. *Lancet Glob Heal.* 2018;6:e1397-1404.

22. Admasu K, Balcha T, Ghebreyesus TA. Pro-poor pathway towards universal health coverage: lessons from Ethiopia. *JOGH*. 2016;6(1).
23. Wang H, Tesfaye R, Ramana GN V, Chekagn CT. Ethiopia Health Extension Program. An institutionalized community approach for universal health coverage. Washington, DC; 2016.
24. Koblinsky M, Tain F, Gaym A, Karim A, Carnell M, Tesfaye S. Responding to the maternal health care challenge : The Ethiopian Health Extension Program. *Ethiop J Heal Dev*. 2010;24(Special Issue 1).
25. Federal Democratic Republic of Ethiopia Ministry of Health. Health Extension Worker Training Manual. Addis Ababa; 2003.
26. Damtew ZA, Karim AM, Chekagn CT, Zemichael NF, Yihun B, Willey BA, et al. Correlates of the Women's Development Army strategy implementation strength with household reproductive, maternal, newborn and child healthcare practices: a cross-sectional study in four regions of Ethiopia. *BMC Pregnancy Childbirth*. 2018;18 (Suppl(373).
27. Banteyerga H. Ethiopia's Health Extension Program: Improving Health through Community Involvement. *MEDICC Rev*. 2011;13(3):46–9.
28. Fetene N, Canavan ME, Megentta A, Linnander E, Tan AX, Nadew K, et al. District-level health management and health system performance. *PLoS One*. 2019;14(2):e0210624.
29. World Health Organization, UNFPA, UNICEF, AMDD. Monitoring Emergency Obstetric Care. A Handbook. Geneva; 2009.
30. Holmer H, Oyerinde K, Meara JG, Gillies R, Liljestrand J, Hagander L. The global met need for emergency obstetric care: A systematic review. *BJOG*. 2015;122:183–9.
31. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. Geneva, Switzerland; 2016.
32. Antenatal care [Internet]. Guide to DHS Statistics DHS7. [cited 2020 Jul 27]. Available from: https://dhsprogram.com/data/Guide-to-DHS-Statistics/Antenatal_Care.htm
33. World Health Organization. World Health Statistics 2010 Indicator compendium Interim version. 2010.
34. World Health Organization. Reproductive Health Indicators. Guidelines for their generation, interpretation and analysis for global monitoring. Geneva; 2006.
35. World Health Organization. Antenatal care coverage [Internet]. [cited 2020 Jul 27]. Available from: <https://www.who.int/whosis/whostat2006AntenatalCareCoverage.pdf>
36. The Partnership for Maternal Newborn and Child Health. Millenium Development Goals 4 and 5 [Internet]. [cited 2020 Jul 27]. Available from: https://www.who.int/pmnch/about/about_mdgs/en/
37. Demographic and Health Surveys: Model Woman's Questionnaire. <https://dhsprogram.com/publications/publication-dhsq7-dhs-questionnaires-and-manuals.cfm>; 2016.
38. World Health Organization. Antenatal care coverage -at least four visits (%) [Internet]. [cited 2020 Jul 27]. Available from: <https://www.who.int/data/gho/indicator-metadata-registry/imr-details/80>
39. World Health Organization. Institutional births (%) [Internet]. [cited 2020 Jul 27]. Available from: <https://www.who.int/data/gho/indicator-metadata-registry/imr-details/5580>
40. MEASURE Evaluation. Percent of births in health facilities [Internet]. [cited 2020 Jul 27]. Available from: https://www.measureevaluation.org/prh/rh_indicators/womens-health/sm/percent-of-births-in-health-facilities
41. Moyer CA, Dako-Gyeke P, Adanu RM. Facility-based delivery and maternal and early

- neonatal mortality in sub-Saharan Africa: A regional review of the literature. *Afr J Reprod Health*. 2013;17(3):30–43.
42. Global SDG Indicator Platform. 3.1.2 Proportion of births attended by skilled health personnel [Internet]. [cited 2020 Jul 27]. Available from: <https://sdg.tracking-progress.org/indicator/3-1-2-proportion-of-births-attended-by-skilled-health-personnel/>
 43. Harvey SA, Blandon YCW, McCaw-Binns A, Sandino I, Urbina L, Rodriguez C, et al. Are skilled birth attendants really skilled? A measurement method, some disturbing results and a potential way forward. *Bull World Health Organ*. 2007 Oct;85(10):783–90.
 44. Radovich E, Benova L, Penn-Kekana L, Wong K, Maeve O, Campbell R. ‘Who assisted with the delivery of (NAME)?’ Issues in estimating skilled birth attendant coverage through population-based surveys and implications for improving global tracking. *BMJ Glob Heal*. 2019;4(e001367).
 45. World Health Organization. WHO recommendations on postnatal care of the mother and newborn. World Health Organization. Geneva; 2013.
 46. Warren C, Daly P, Toure L, Mongi P. Postnatal care. In: Opportunities for Africa’s newborns. 2006. p. 79–90.
 47. Postnatal care [Internet]. Guide to DHS Statistics DHS7. [cited 2020 Feb 13]. Available from: https://dhsprogram.com/data/Guide-to-DHS-Statistics/Postnatal_Care.htm
 48. Amouzou A, Hazel E, Sanni Y. Discordance in postnatal care between mothers and newborns : Measurement artifact or missed. *J Glob Health*. 2020;10(1).
 49. Central Statistical Authority. Ethiopia Demographic & Health Survey (2000). Addis Ababa & Calverton; 2001.
 50. Ethiopian Public Health Institute. Mini Demographic & Health Survey (2019). Addis Ababa and Rockville, Maryland; 2019.
 51. Central Statistical Agency. Ethiopia Demographic and Health Survey (2005). Addis Ababa & Calverton; 2006.
 52. Central Statistical Agency. Ethiopia Demographic & Health Survey (2011). Addis Ababa & Calverton; 2011.
 53. Central Statistical Agency. Ethiopia Mini Demographic and Health Survey. Addis Ababa; 2014.
 54. Central Statistical Agency. Ethiopia Demographic & Health Survey (2016). Addis Ababa and Rockville, Maryland; 2017.
 55. Medhanyie A, Spigt M, Dinant G, Blanco R. Knowledge and performance of the Ethiopian health extension workers on antenatal and delivery care: a cross-sectional study. *Hum Resour Health*. 2012;10(44).
 56. Jackson R, Hailemariam A. The role of health extension workers in linking pregnant women with health facilities for delivery in rural and pastoralist areas of Ethiopia. *Ethiop J Health Sci*. 2016;26(5):471–8.
 57. Federal Democratic Republic of Ethiopia Ministry of Health. Health Sector Development Programme IV (2010/11 - 2014/15). Addis Ababa; 2010.
 58. Bergen N, Zhu G, Yedenekal SA, Mamo A, Gebretsadik LA, Morankar S, et al. Promoting equity in maternal , newborn and child health – how does gender factor in ? Perceptions of public servants in the Ethiopian health sector. *Glob Health Action*. 2020;13(1704530).
 59. Desta AF, Shifa GT, Dagoye DW, Carr C, van Roosmalen J, Stekelenburg J, et al. Identifying gaps in the practices of rural health extension workers in Ethiopia : a task analysis study. *BMC Health Serv Res*. 2017;17(839).

60. Okedo-Alex IN, Akamike IC, Ezeanosike OB, Uneke CJ. Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. *BMJ Open*. 2019 Oct;9(10):e031890.
61. Makate M, Makate C. Prenatal care utilization in Zimbabwe: Examining the role of community-level factors. *J Epidemiol Glob Health*. 2017;7:255–62.
62. Ononokpono DN, Odimegwu CO, Imasiku E, Adedini S. Contextual Determinants of Maternal Health Care Service Utilization in Nigeria. *Women Health*. 2013;53:647–68.
63. Guliani H, Sepehri A, Serieux J. Determinants of prenatal care use: Evidence from 32 low-income countries across Asia, Sub-Saharan Africa and Latin America. *Health Policy Plan*. 2014;29:589–602.
64. Tekelab T, Chojenta C, Smith R, Loxton D. Factors affecting utilization of antenatal care in Ethiopia: A systematic review and meta- analysis. *PLoS One*. 2019;14(4):e0214848.
65. Ayele DZ, Belayihun B, Teji K, Ayana DA. Factors Affecting Utilization of Maternal Health Care Services in Kombolcha District, Eastern Hararghe Zone, Oromia Regional State, Eastern Ethiopia. *Int Sch Res Not*. 2014;2014(Article ID: 917058).
66. Birmeta K, Dibaba Y, Woldeyohannes D. Determinants of maternal health care utilization in Holeta town, central Ethiopia. *BMC Health Serv Res*. 2013;13(256).
67. Jira C, Belachew T. Determinants of antenatal care utilization in Jimma Town, Southwest Ethiopia. *Ethiop J Health Sci*. 2005;15(1):49–61.
68. Abosse Z, Woldie M, Ololo S. Factors influencing antenatal care service utilization in Hadiya Zone. *Ethiop J Health Sci*. 2010;20(2).
69. Fekede B, Gebremariam AG. Antenatal care service utilization and factors associated in Jimma Town, Southwest Ethiopia. *Ethiop Med J*. 2007;45(2):123–33.
70. Regassa N. Antenatal and postnatal care service utilization in Southern Ethiopia: A population-based study. *Afr Health Sci*. 2011;11(3):390–7.
71. Tewodros B, Gebremariam A, Dibaba Y. Factors affecting antenatal care utilization in Yem special woreda, southwestern Ethiopia. *Ethiop J Heal Sci*. 2009;19(1):45–50.
72. Dutamo Z, Assefa N, Egata G. Maternal health care use among married women in Hossaina, Ethiopia. *BMC Health Serv Res*. 2015;15(365).
73. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. *BMC Pregnancy Childbirth*. 2014;14(161).
74. Amentie M, Abera M, Abdulahi M. Utilization of Antenatal Care Services and Influencing Factors among Women of Child Bearing Age in Assosa District, Benishangul Gumuz Regional State, West Ethiopia. *Glob J Med Res Gynaecol Obstet*. 2015;15(2).
75. Girmaye M, Berhan Y. Skilled Antenatal Care Service Utilization and Its Association with the Characteristics of Women ' s Health Development Team in Yeky District , South-West Ethiopia : A Multilevel Analysis. *Ethiop J Heal Sci*. 2016;26(4):369–80.
76. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia : a multilevel analysis. *BMC Int Heal Hum Rights*. 2013;13(20).
77. Diamond-Smith N, Sudhinaraset M. Drivers of facility deliveries in Africa and Asia: regional analyses using the demographic and health surveys. *Reprod Health*. 2015;12(6).
78. Tey N-P, Lai S. Correlates of and Barriers to the Utilization of Health Services for Delivery in South Asia and Sub-Saharan Africa. *Sci World J*. 2013;2013(Article ID 423403).
79. Bohren MA, Hunter EC, Munthe-Kaas HM, Souza J, Vogel JP, Gülmezoglu A. Facilitators and barriers to facility-based delivery in low- and middle-income countries: a qualitative evidence synthesis. *Reprod Health*. 2014;11(71).

80. Wong KLM, Benova L, Campbell OMR. A look back on how far to walk: Systematic review and meta-analysis of physical access to skilled care for childbirth in Sub-Saharan Africa. *PLoS One*. 2017;12(9).
81. Nigusie A, Azale T, Yitayal M. Institutional delivery service utilization and associated factors in Ethiopia: a systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2020;20(364).
82. Kebede A, Hassen K, Teklehaymanot AN. Factors associated with institutional delivery service utilization in Ethiopia. *Int J Womens Health*. 2016;8:463–75.
83. Abebe F, Berhane Y, Girma B. Factors associated with home delivery in Bahirdar, Ethiopia : A case control study. *BMC Res Notes*. 2012;5(653).
84. Fikre AA, Demissie M. Prevalence of institutional delivery and associated factors in Dodota Woreda (district), Oromia regional state, Ethiopia. *Reprod Health*. 2012;9(33).
85. Hagos S, Shaweno D, Assegid M, Mekonnen A, Afework MF, Ahmed S. Utilization of institutional delivery service at Wukro and Butajera districts in the Northern and South Central Ethiopia. *BMC Pregnancy Childbirth*. 2014;14(178).
86. Odo DB, Shifti DM. Institutional delivery service utilization and associated factors among child bearing age women in Goba Woreda, Ethiopia. *J Gynecol Obstet*. 2014;2(4):63–70.
87. Wado YD, Afework MF, Hindin MJ. Unintended pregnancies and the use of maternal health services in Southwestern Ethiopia. *BMC Int Heal Hum Rights*. 2013;13(36).
88. Langlois É V, Miszkurka M, Victoria M, Ghaffar A, Ziegler D, Karp I. Inequities in postnatal care in low- and middle-income countries: a systematic review and meta-analysis. *Bull World Health Organ*. 2015;93:259–70.
89. Mukonka PS, Mukwato PK, Kwaleyela CN, Mweemba O, Maimbola M. Household factors associated with use of postnatal care services. *Afr J Midwifery Womens Health*. 2018;12(4):189–93.
90. Benova L, Owolabi O, Radovich E, Wong KLM, Macleod D, Langlois E V., et al. Provision of postpartum care to women giving birth in health facilities in sub-Saharan Africa: A cross-sectional study using Demographic and Health Survey data from 33 countries. *PLOS Med*. 2019;16(10):e1002943.
91. Chaka EE, Abdurahman AA, Nedjat S, Majdzadeh R. Utilization and Determinants of Postnatal Care Services in Ethiopia : A Systematic Review and Meta-Analysis. *Ethiop J Heal Sci*. 2019;29(1):935–44.
92. Downe S, Finlayson K, Tunçalp Ö, Gülmezoglu A. Provision and uptake of routine antenatal care services: a qualitative evidence synthesis (review). *Cochrane Database Syst Rev*. 2019;6(Art No:CD012392).
93. Moyer CA, Mustafa A. Drivers and deterrents of facility delivery in sub-Saharan Africa: a systematic review. *Reprod Health*. 2013;10(40).
94. Moyer CA, Adongo PB, Aborigo RA, Hodgson A, Engmann CM, Devries R. “It’s up to the woman’s people”: How social factors influence facility-based delivery in Rural Northern Ghana. *Matern Child Health J*. 2014;18:109–19.
95. Crissman HP, Engmann CE, Adanu RM, Nimako D, Crespo K, Moyer CA. Shifting norms: pregnant women’s perspectives on skilled birth attendance and facility-based delivery in rural Ghana. *Afr J Reprod Health*. 2013;17(1):15–26.
96. Kitui J, Lewis S, Davey G. Factors influencing place of delivery for women in Kenya: an analysis of the Kenya demographic and health survey, 2008/2009. *BMC Pregnancy Childbirth*. 2013;13(40).
97. Teferra AS, Alemu FM, Woldeyohannes SM. Institutional delivery service utilization and associated factors among mothers who gave birth in the last 12 months in Sekela District,

- North West of Ethiopia : A community-based cross sectional study. *BMC Pregnancy Childbirth*. 2012;12(74).
98. Kumbani L, Bjune G, Chirwa E, Malata A, Odland JØ. Why some women fail to give birth at health facilities: a qualitative study of women's perceptions of perinatal care from rural Southern Malawi. *Reprod Health*. 2013;10(1):9.
 99. Pfeiffer C, Mwaipopo R. Delivering at home or in a health facility? health-seeking behaviour of women and the role of traditional birth attendants in Tanzania. *BMC Pregnancy Childbirth*. 2013;13(55).
 100. Rothman KJ, Greenland S, Lash TL. Chapter 9- Validity in Epidemiologic Studies. In: *Modern Epidemiology*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2008. p. 1–9.
 101. Harrell FE. *Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression and Survival Analysis*. New York: Springer Science and Business Media; 2001.
 102. Liang K-Y, Zeger SL. Regression analysis for correlated data. *Annu Rev Public Health*. 1993;14:43–68.
 103. Galbraith S, Daniel JA, Vissel B. A study of clustered data and approaches to its analysis. *J Neurosci*. 2010;30(32):10601–8.
 104. McNeish DM, Harring JR. Clustered data with small sample sizes: Comparing the performance of model-based and design-based approaches. *Commun Stat Simul Comput*. 2017;46(2):855–69.
 105. Clarke P. When can group level clustering be ignored? Multilevel models versus single-level models with sparse data. *J Epidemiol Community Heal*. 2008;62:752–8.
 106. Yebyo HG, Gebreselassie MA, Kahsay AB. Individual and community-level predictors of home delivery in Ethiopia: A multilevel mixed-effects analysis of the 2011 Ethiopia National Demographic and Health Survey. *DHS Working Papers No. 104*. 2014.
 107. Kruk ME, Rockers PC, Mbaruku G, Paczkowski MM, Galea S. Community and health system factors associated with facility delivery in rural Tanzania: A multilevel analysis. *Health Policy (New York)*. 2010;97:209–16.
 108. Stephenson R, Baschieri A, Clements S, Hennink M, Madise N. Contextual influences on the use of health facilities for childbirth in Africa. *Am J Public Health*. 2006;96:84–93.
 109. Aremu O, Lawoko S, Dalal K. Neighborhood socioeconomic disadvantage, individual wealth status and patterns of delivery care utilization in Nigeria: a multilevel discrete choice analysis. *Int J Womens Health*. 2011;3:167–74.
 110. Fotheringham AS, Brunsdon C, Charlton M. *Geographically weighted regression*. Chichester: John Wiley & Sons Ltd; 2002.
 111. World Health Organization. *Maternity Waiting Homes: A review of experiences*. Geneva; 1996.
 112. Wilson JB, Collison AHK, Richardson D, Kwofie G, Senah KA, Tinkorang EK. The maternity waiting home concept: The Nsawam, Ghana experience. *Int J Gynecol Obstet*. 1997;59(Suppl.2):S165–72.
 113. Wild K, Barclay L, Kelly P, Martins N. The tyranny of distance: Maternity waiting homes and access to birthing facilities in rural Timor-Leste. *Bull World Health Organ*. 2012;90(2):97–103.
 114. Bonawitz R, McGlasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia : A mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS One*. 2019;14(11):e0225523.

115. Chandramohan D, Cutts F, Chandra R. Effects of a maternity waiting home on adverse maternal outcomes and the validity of antenatal risk screening. *Int J Gynecol Obstet*. 1994;46(3):279–84.
116. Chibuye PS, Bazant ES, Wallon M, Rao N, Fruhauf T. Experiences with and expectations of maternity waiting homes in Luapula Province, Zambia: a mixed – methods, cross-sectional study with women, community groups and stakeholders. *BMC Pregnancy Childbirth*. 2018;18(42).
117. McIntosh N, Gruits P, Oppel E, Shao A. Built spaces and features associated with user satisfaction in maternity waiting homes in Malawi. *Midwifery*. 2018;62:96–103.
118. World Health Organization. Namibia : Maternity waiting homes protect newborns and mothers [Internet]. 2016 [cited 2020 May 1]. Available from: <https://www.who.int/news-room/feature-stories/detail/namibia-maternity-waiting-homes-protect-newborns-and-mothers>
119. Shrestha SD, Rajendra PK, Shrestha N. Feasibility study on establishing Maternity Waiting Homes in remote areas of Nepal. *Reg Heal Forum*. 2007;11(2).
120. van Lonkhuijzen L, Stegeman M, Nyirongo R, van Roosmalen J. Use of maternity waiting home in rural Zambia. *Afr J Reprod Health*. 2003 Apr;7(1):32–6.
121. Penn-Kekana L, Pereira S, Hussein J, Bontogon H, Chersich M, Munjanja S, et al. Understanding the implementation of maternity waiting homes in low- and middle-income countries: A qualitative thematic synthesis. *BMC Pregnancy Childbirth*. 2017;17(269).
122. Lori JR, Wadsworth AC, Munro ML, Rominski S. Promoting access: The use of maternity waiting homes to achieve safe motherhood. *Midwifery*. 2013;29:1095–102.
123. Ruiz MJ, van Dijk MG, Berdichevsky K, Munguía A, Burks C, García SG. Barriers to the use of maternity waiting homes in indigenous regions of Guatemala: A study of users' and community members' perceptions. *Cult Heal Sex*. 2013;15(2):205–18.
124. Andemichael G, Haile B, Kosia A, Mufunda J. Maternity waiting homes: A panacea for maternal/neonatal conundrums in Eritrea. *J Eritrean Med Assoc*. 2010;4(1):18–21.
125. Fogliati P, Straneo M, Mangi S, Azzimonti G, Kisika F, Putoto G. A new use for an old tool: Maternity waiting homes to improve equity in rural childbirth care. Results from a cross-sectional hospital and community survey in Tanzania. *Health Policy Plan*. 2017;32:1354–60.
126. Lori JR, Boyd CJ, Munro-Kramer ML, Veliz PT, Henry EG, Kaiser J, et al. Characteristics of maternity waiting homes and the women who use them: Findings from a baseline cross-sectional household survey among SMGL-supported districts in Zambia. *PLoS One*. 2018;13(12).
127. Stollak I, Valdez M, Rivas K, Perry H. Casas Maternas in the Rural Highlands of Guatemala: A Mixed-Methods Case Study of the Introduction and Utilization of Birthing Facilities by an Indigenous Population. *Glob Heal Sci Pract*. 2016;4(1):114–31.
128. Garcia Prado A, Cortez R. Maternity waiting homes and institutional birth in Nicaragua: policy options and strategic implications. *Int J Health Plann Manage*. 2012;27:150–66.
129. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynaecol Obstet*. 2010;108:152–3.
130. Singh K, Speizer I, Kim ET, Lemani C, Phoya A. Reaching vulnerable women through maternity waiting homes in Malawi. *Int J Gynaecol Obstet*. 2017;136:91–7.
131. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiters RAC. Improving access to skilled facility-based delivery services: Women's beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;12(61).
132. Suwedi-Kapesa L, Nyondo-Mipando A. Assessment of the quality of care in Maternity Waiting Homes (MWHs) in Mulanje District, Malawi. *Malawi Med J*. 2018;2:103–10.

133. Sundu S, Mwale OG, Chirwa E. Antenatal Mothers ' Experience of Staying in a Maternity Waiting Home at Malamulo Mission Hospital in Thyolo District Malawi : A Qualitative , Exploratory Study. *Women's Heal Gynecol Heal Gynecol*. 2017;3(1).
134. Schooley J, Mundt C, Wagner P, Fullerton J, O'Donnell M. Factors influencing health care-seeking behaviours among Mayan women in Guatemala. *Midwifery*. 2009;25(4):411–21.
135. Lori JR, Perosky JE, Rominski S, Munro-Kramer ML, Cooper F, Kofa A, et al. Maternity waiting homes in Liberia: Results of a countrywide multi-sector scale-up. *PLoS One*. 2020;15(6):e0234785.
136. World Health Organization. Every Pregnancy Faces Risk [Internet]. 1998 [cited 2016 Apr 20]. Available from: https://www.who.int/docstore/world-health-day/en/pages1998/whd98_05.html
137. Tsui AO, Wasserheit JN, Haaga JG, editors. *Reproductive Health in Developing Countries: Expanding Dimensions, Building Solutions*. Washington, DC: National Academy Press; 1997.
138. Berglund A, Lindmark G. The usefulness of initial risk assessment as a predictor of pregnancy complications and premature delivery. *Acta Obstet Gynecol Scand*. 1999;78:871–6.
139. Danilack VA, Nunes AP, Phipps MG. Unexpected complications of low-risk pregnancies in the United States. *Am J Obstet Gynecol*. 2015;212(6):809.e1-809.e6.
140. World Health Organization. *WHO Recommendations on health promotion interventions for maternal and newborn health*. Geneva, Switzerland; 2015.
141. Chandramohan D, Cutts F, Millard P. The effect of stay in a maternity waiting homes on perinatal mortality. *J Trop Med Hyg*. 1995;98:261–7.
142. Figa'-Talamanca I. Maternal mortality and the problem of accessibility to obstetric care: the strategy of waiting homes. *Soc Sci Med*. 1996;42(10):1381–90.
143. Balcom K. Scandal and Social Policy: The Ideal Maternity Home and the Evolution of Social Policy in Nova Scotia, 1940-51. *Acadiensis J Hist Atl Reg*. 2002;31(2):3–37.
144. Wallace HM, Goldstein H, Gold EM, Oglesby AC. The Maternity Home. Present Services and Future Roles. *Am J Public Health*. 1972;64(6):568–75.
145. Poovan P, Kifle F, Kwast BE. A maternity waiting home reduces obstetric catastrophes. *World Health Forum*. 1990;11(4):440–5.
146. Kingdom of Cambodia Ministry of Health. *National Reproductive Health Program: National Guideline On Waiting Home*. 2010.
147. Satti H, McLaughlin M, Seung KJ. The Role of Maternity Waiting Homes as part of a comprehensive maternal mortality reduction strategy in Lesotho. Vol. 1. 2013.
148. UNICEF. Bamyam maternity waiting home: A safe place to give birth in Afghanistan [Internet]. 2010 [cited 2017 Aug 10]. Available from: https://www.unicef.org/health/afghanistan_54272.html
149. UNICEF. *Innovative Approaches to Maternal and Newborn Health. Compendium of Case Studies*. New York; 2013.
150. Gao Y, Zhou H, Singh NS, Powell-Jackson T, Nash S, Yang M, et al. Progress and challenges in maternal health in western China: a Countdown to 2015 national case study. *Lancet Glob Heal*. 2017;5:e523-36.
151. UNICEF. Maternity waiting homes. Promoting institutional delivery and pregnant women's access to skilled care [Internet]. 2013 [cited 2020 Apr 21]. Available from: <https://zimbabwe.unfpa.org/sites/default/files/pub-pdf/MATERNITYWAITINGHOMES.SUMMARY.pdf>
152. UNFPA Zimbabwe. UNFPA supports refurbishment of maternity waiting homes at 20 sites [Internet]. 2011 [cited 2020 Apr 13]. Available from: www.countryoffice.unfpa.org/zimbabwe

153. Lori JR, Munro ML, Rominski S, Williams G, Dahn BT, Boyd CJ, et al. Maternity waiting homes and traditional midwives in rural Liberia. *Int J Gynecol Obstet*. 2013;123:114–8.
154. Rai C, Rana H, Paudel M, Manandhar D, Shreshtha J, Adhikari D. Strengthening health facility operation and management committees to improve maternal and newborn health status in peripheral health facilities of Arghakhanchi, Nepal. 2013.
155. HealthRight International. Final Project Report. 2014.
156. Vermeiden T, Schiffer R, Langhorst J, Klappe N, Asera W, Getnet G, et al. Facilitators for maternity waiting home utilisation at Attat Hospital: a mixed-methods study based on 45 years of experience. *Trop Med Int Heal*. 2018;23(12):1332–41.
157. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
158. Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa; 2015.
159. Federal Democratic Republic of Ethiopia Ministry of Health. National Reproductive Health Strategy (2016-2020). Addis Ababa; 2016.
160. UNFPA Supported Maternity Waiting Homes in Ethiopia. 2018.
161. Buser JM, Lori JR. Newborn Outcomes and Maternity Waiting Homes in Low and Middle-Income Countries: A Scoping Review. *Matern Child Health J*. 2016;1–10.
162. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
163. Mutea F. Enhancing skilled deliveries through maternal shelters in Nachola dispensary, Samburu County, Kenya. In: *Global Maternal Newborn Health Conference*. 2015.
164. Henry EG, Semrau K, Hamer DH, Vian T, Nambao M, Mataka K, et al. The influence of quality maternity waiting homes on utilization of facilities for delivery in rural Zambia. *Reprod Health*. 2017;14(68).
165. Scott NA, Henry EG, Kaiser JL, Hamer DH, Munro-kramer ML, Lori JR. Factors affecting home delivery among women living in remote areas of rural Zambia : a cross-sectional , mixed-methods analysis. *Int J Womens Health*. 2018;10:589–601.
166. Perosky JE, Lockhart MLMN, Musonda GK, Naggayi A, Lori JR. Maternity waiting homes as an intervention to increase facility delivery in rural Zambia. *Int J Gynaecol Obstet*. 2019;266–7.
167. van den Heuvel OA. Use of maternal care in a rural area of Zimbabwe:a population-based study. *Acta Obstet Gynecol Scand*. 1999;78:838–46.
168. Lori JR, Perosky J, Munro-kramer ML, Veliz P, Musonda G, Kaunda J, et al. Maternity waiting homes as part of a comprehensive approach to maternal and newborn care : a cross-sectional survey. *BMC Pregnancy Childbirth*. 2019;19(228).
169. Eckermann E, Deodato G. Maternity waiting homes in Southern Lao PDR: The unique “silk home.” *J Obstet Gynaecol Res*. 2008;34(5):767–75.
170. Kyokan M, Whitney-long M, Kuteh M, Raven J. Community-based birth waiting homes in Northern Sierra Leone: Factors influencing women’s use. *Midwifery*. 2016;39:49–56.
171. Lori JR, Munro-Kramer ML, Mdluli EA, Musonda GK, Boyd CJ. Developing a community driven sustainable model of maternity waiting homes for rural Zambia. *Midwifery*. 2016;41:89–95.
172. Tiruneh GT, Taye BW, Karim AM, Betemariam WA, Zemichael NF, Wereta TG, et al. Maternity waiting homes in Rural Health Centers of Ethiopia: The situation, women’s

- experiences and challenges. *J Heal Dev.* 2016;30(1):19–28.
173. Scott NA, Vian T, Kaiser JL, Ngoma T, Mataka K, Henry EG, et al. Listening to the community: Using formative research to strengthen maternity waiting homes in Zambia. *PLoS One.* 2018;13(3).
 174. Kebede KM, Mihrete KM. Factors influencing women's access to the maternity waiting home in rural Southwest Ethiopia: a qualitative exploration. *BMC Pregnancy Childbirth.* 2020;20(296).
 175. Braat F, Vermeiden T, Getnet G, Schiffer R, van den Akker T, Stekelenburg J. Comparison of pregnancy outcomes between maternity waiting home users and non-users at hospitals with and without a maternity waiting home: retrospective cohort study. *Int Health.* 2018;10:47–53.
 176. Dari AT, Aulia D. Association between Socialization and the Use of Maternity Waiting Home in East Aceh, Indonesia. *J Heal Policy Manag.* 2019;4(2):86–90.
 177. Singh K, Speizer IS, Kim ET, Lemani C, Tang JH, Phoya A. Evaluation of a maternity waiting home and community education program in two districts of Malawi. *BMC Pregnancy Childbirth pregnancy childbirth.* 2018;18(457).
 178. Getachew B, Liabsuetrakul T, Gebrehiwot Y. Association of maternity waiting home utilization with women's perceived geographic barriers and delivery complications in Ethiopia. *Int J Heal Plan Manag.* 2019;1–12.
 179. Bergen N, Abebe L, Asfaw S, Kiros G, Kulkarni MA. Maternity waiting areas – serving all women ? Barriers and enablers of an equity-oriented maternal health intervention in Jimma Zone, Ethiopia. *Glob Public Health.* 2019;14(10):1509–23.
 180. Lori JR, Munro-Kramer ML, Shifman J, Amarah PNM, Williams G. Patient Satisfaction With Maternity Waiting Homes in Liberia: A Case Study During the Ebola Outbreak. *J Midwifery Womens Health.* 2017;62:163–71.
 181. Hossain SK, Porter EL, Redden LM, Pearlmutter MD. Maternity Waiting Home Use and Maternal Mortality in Milot, Haiti. *Obstet Gynecol.* 2014;123(5):149S–150S.
 182. Endalew GB, Gebretsadik AL, Gizaw TA. Intention to use Maternity Waiting Home among Pregnant Women in Jimma District, Southwest Ethiopia. *Glob J Med Res.* 2016;16(6):1–8.
 183. Sialubanje C, Massar K, Hamer DH, Ruiter RAC. Personal and environmental factors associated with the utilisation of maternity waiting homes in rural Zambia. *BMC Pregnancy Childbirth.* 2017;17(136).
 184. Vermeiden T, Braat F, Medhin G, Gaym A, van den Akker T, Stekelenburg J. Factors associated with intended use of a maternity waiting home in Southern Ethiopia: A community-based cross-sectional study. *BMC Pregnancy Childbirth.* 2018;18(38).
 185. Endayehu M, Yitayal M, Debie A. Intentions to use maternity waiting homes and associated factors in Northwest Ethiopia. *BMC Pregnancy Childbirth.* 2020;20(281).
 186. Definition of leader [Internet]. Cambridge Dictionary. 2020 [cited 2020 Jul 21]. Available from: <https://dictionary.cambridge.org/dictionary/english/leader>
 187. Sullivan H, Downe J, Entwistle TOM, Sweeting D. The Three Challenges of Community Leadership. *Local Gov Stud.* 2006;32(4):489–508.
 188. Lamm KW, Carter H, Lamm A, Lindsey A. Community Leadership : A Theory-Based Model. *J Leadersh Educ.* 2017;(July):118–33.
 189. Schaaf M, Warthin C, Freedman L, Topp SM. The community health worker as service extender, cultural broker and social change agent: a critical interpretive synthesis of roles, intent and accountability. *BMJ Glob Heal.* 2020;5(e002296).
 190. Dynes MM, Stephenson R, Hadley C, Sibley LM. Factors Shaping Interactions Among

- Community Health Workers in Rural Ethiopia: Rethinking Workplace Trust and Teamwork. *J Midwifery Women's Heal*. 2014;59:S32–43.
191. Kok MC, Ormel H, Broerse JEW, Kane S, Namakhoma I, Otiso L, et al. Optimising the benefits of community health workers' unique position between communities and the health sector : A comparative analysis of factors shaping relationships in four countries. *Glob Public Health*. 2017;12(11):1404–32.
 192. Jackson R, Tesfay FH, Godefay H, Gebrehiwot TG. Health extension workers' and mothers' attitudes to maternal health service utilization and acceptance in Adwa Woreda, Tigray Region, Ethiopia. *PLoS One*. 2016;11(3):e0150747.
 193. Karim AM, Admassu K, Schellenberg J, Alemu H, Getachew N, Ameha A, et al. Effect of Ethiopia's Health Extension Program on Maternal and Newborn Health Care Practices in 101 Rural Districts: A Dose-Response Study. *PLoS One*. 2013;8(6):e65160.
 194. Yitbarek K, Abraham G, Sudhakar M. Contribution of women's development army to maternal and child health in Ethiopia: a systematic review of evidence. *BMJ Open*. 2019;9(e025937).
 195. Afework MF, Admassu K, Mekonnen A, Hagos S, Asegid M, Ahmed S. Effect of an innovative community based health program on maternal health service utilization in north and south central Ethiopia : a community based cross sectional study. *Reprod Health*. 2014;11(28).
 196. Rieger M, Wagner N, Mebratie A, Alemu G, Bedi A. The impact of the Ethiopian health extension program and health development army on maternal mortality : A synthetic control approach. *Soc Sci Med*. 2019;232:374–81.
 197. Blanchard AK, Prost A, Houweling TAJ. Effects of community health worker interventions on socioeconomic inequities in maternal and newborn health in low-income and middle-income countries : a mixed-methods systematic review. *BMJ Glob Heal*. 2019;4:e001308.
 198. Kane S, Kok M, Ormel H, Otiso L, Sidat M, Namakhoma I, et al. Limits and opportunities to community health worker empowerment: A multi-country comparative study. *Soc Sci Med*. 2016;164:27–34.
 199. Kyei-Nimakoh M, Carolan-Olah M, McCann T V. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. *Syst Rev*. 2017;6(110).
 200. Maternal and Child Health Integrated Program. Cultural Barriers to Seeking Maternal Health Care in Ethiopia: A Review of the Literature. 2012.
 201. Agadjanian V, Yabiku ST. Religious affiliation and fertility in a Sub-Saharan context: dynamic and lifetime perspectives. *Popul Res Policy Rev*. 2014;33(5):673–91.
 202. Schiller PL, Levine JS. Is there a religious factor in health care utilization: a review. *Soc Sci Med*. 1988;27(12):1369–79.
 203. Padela AI, Zaidi D. The Islamic tradition and health inequities: A preliminary conceptual model based on a systematic literature review of Muslim health - care disparities. *Avicenna J Med*. 2018;8:1–13.
 204. Kahissay MH, Fenta TG, Boon H. Religion , Spirits , Human Agents and Healing : A Conceptual Understanding from a Sociocultural Study of Tehuledere. *J Relig Health*. 2020;59(2):946–60.
 205. Aradeon S, Doctor H V. Reducing rural maternal mortality and the equity gap in northern Nigeria : the public health evidence for the Community Communication Emergency Referral strategy. *Int J Womens Health*. 2016;8:77–92.
 206. Paudel M, Javanparast S, Dasvarma G, Newman L. Religio-cultural factors contributing to perinatal mortality and morbidity in mountain villages of Nepal : Implications for future healthcare provision. *PLoS One*. 2018;13(3).

207. Kenneth DM, Marvellous M, Stanzia M. Praying until Death : Apostolicism , Delays and Maternal Mortality in Zimbabwe. *PLoS One*. 2016;11(8).
208. Lawoyin T, Lawoyin O, Adewole D. Men's Perception of Maternal Mortality in Nigeria. *J Public Health Policy*. 2007;28:299–318.
209. Serizawa A, Ito K, Algaddal AH, Eltaybe RAM. Cultural perceptions and health behaviors related to safe motherhood among village women in Eastern Sudan: Ethnographic study. *Int J Nurs Stud*. 2014;51:572–81.
210. Adedini S, Babalola S, Ibeawuchi C, Omotoso O, Akiode A, Odeku M. Role of Religious Leaders in Promoting Contraceptive Use in Nigeria: Evidence From the Nigerian Urban Reproductive Health Initiative. *Glob Heal Sci Pract*. 2018;6(3):500–14.
211. Hembling J, Mcewan E, Ali M, Passaniti A, Aryee P, Saaka M. Mobilising faith-based and lay leaders to address antenatal care outcomes in northern Ghana. *Dev Pract*. 2017;27(5):634–45.
212. Endeshaw M, Alemu S, Andrews N, Dessie A, Frey S. Involving religious leaders in HIV care and treatment at a university-affiliated hospital in Ethiopia: Application of formative inquiry. *Glob Public Health*. 2017;12(4):416–31.
213. Walker J, Hashim Y, Oranye N. Impact of Muslim opinion leaders' training of healthcare providers on the uptake of MNCH services in Northern Nigeria. *Glob Public Health*. 2019;14(2):200–13.
214. Widmer M, Betran AP, Merialdi M, Requejo J, Karpf T. The role of faith-based organizations in maternal and newborn health care in Africa. *Int J Gynaecol Obstet*. 2011;114:218–22.
215. Erin B, Anderson A. 'One Hand Can't Clap by Itself': Engagement of Boys and Men in Kembatti Mentti Gezzimma's Intervention to Eliminate Female Genital Mutilation and Circumcision in Kembatta Zone, Ethiopia EMERGE Case Study 3. 2015.
216. Trintapoli J. The AIDS-related activities of religious leaders in Malawi. *Glob Public Health*. 2011;6(1):41–55.
217. Nkwonta CA, Messias D. Male Participation in Reproductive Health Interventions in Sub-Saharan Africa: A Scoping Review. *Int Perspect Sex Heal*. 2019;45:71–86.
218. Byrne A, Hodge A, Jimenez-soto E, Morgan A. What Works ? Strategies to Increase Reproductive, Maternal and Child Health in Difficult to Access Mountainous Locations: A Systematic Literature Review. *PLoS One*. 2014;9(2):e87683.
219. Sundararajan R, Yoder LM, Kihunrwa A, Aristide C, Kalluvya SE, Downs DJ, et al. How gender and religion impact uptake of family planning : results from a qualitative study in Northwestern Tanzania. *BMC Womens Health*. 2019;19(99).
220. Mushi D, Mpembeni R, Jahn A. Effectiveness of community based Safe Motherhood promoters in improving the utilization of obstetric care. The case of Mtwara Rural District in Tanzania. *BMC Pregnancy Childbirth*. 2010;10(14).
221. Mamo A, Morankar S, Asfaw S, Bergen N, Kulkarni MA, Abebe L, et al. How do community health actors explain their roles ? Exploring the roles of community health actors in promoting maternal health services in rural Ethiopia. *BMC Health Serv Res*. 2019;7(24).
222. Kea AZ, Tulloch O, Datiko DG, Theobald S, Kok MC. Exploring barriers to the use of formal maternal health services and priority areas for action in Sidama zone, southern Ethiopia. *BMC Pregnancy Childbirth*. 2018;18(96).
223. Millard P, Bailey J, Hanson J. Antenatal village stay and pregnancy outcome in rural Zimbabwe. *Cent Afr J Med*. 1991;37(1).
224. Pimenta AM, Nazareth JV, Souza KV De, Pimenta GM. "The House of Pregnant Women" Program: user profile and maternal and perinatal health care results. *Text Context Nurs*. 2012;21(4):912–20.

Chapter 3. Methods

While the methodological details pertaining to each article are covered within their respective chapters, I present additional information here about the study setting to provide context and include more details about crucial elements of my research. I explain how, under the guidance of Dr. Monica Taljaard (thesis advisory committee member), I calculated the sample size for the cluster-randomized controlled trial (section 3.2), how I led the design of the household surveys (which are the main data sources for my thesis) (section 3.3) and how Dr. Manisha Kulkarni (thesis supervisor) and I sampled women for the surveys (section 3.4). I also systematically describe how the maternity waiting home (MWH⁺) intervention component was developed (section 3.5). In the final sections of this chapter, I expound on fundamental aspects of spatial (section 3.6) and trial analysis (section 3.7) methods to complement the condensed versions included within the articles. Copies of ethical approvals obtained are included in Appendix 3.1.

3.1. Study setting

3.1.1. Ethiopia

The trial, within which this research is nested, was conducted in three districts in Jimma Zone (Figure 3.1c), located within Oromia region (Figure 3.1b) in the south-western part of the country. Ethiopia is land-locked and situated in the Horn of Africa (Figure 3.1a), with Somalia, Kenya, South Sudan, Eritrea and Sudan along its borders. It is spread across about one million square kilometres, with 36% of the area cultivated for agricultural purposes in 2016.⁽¹⁾ There were an estimated 109 million people in 2018 in Ethiopia and the overall life expectancy at birth was 66 years in 2017.⁽²⁾ In 2017, about half of the population in Ethiopia was above 15 years and women between the ages of 20 and 24 years constituted approximately 10% of the total population. The total fertility rate was 4.3 births per woman in 2017; this was slightly lower than the average for Sub-Saharan Africa (4.8 births per woman) but double the world average (2.4 births per woman).⁽²⁾ Classified as a low-income country by the World Bank¹, agriculture represents 65% of total employment in the country as almost 80% of the country's population is rural. The overall primary school completion rate was 54% in 2015. Ethiopia's literacy rates are below the average in Sub-Saharan Africa and one of the lowest in East Africa.⁽²⁾ Internet use in Ethiopia is also generally low (19%) and concentrated among the urban, the highest educated and the wealthiest segments of the population with large disparities between men and women.⁽³⁾

¹ Countries that had a Gross National Income per capita that was \$1,035 or less in 2019 are classified by the World Bank as low income.

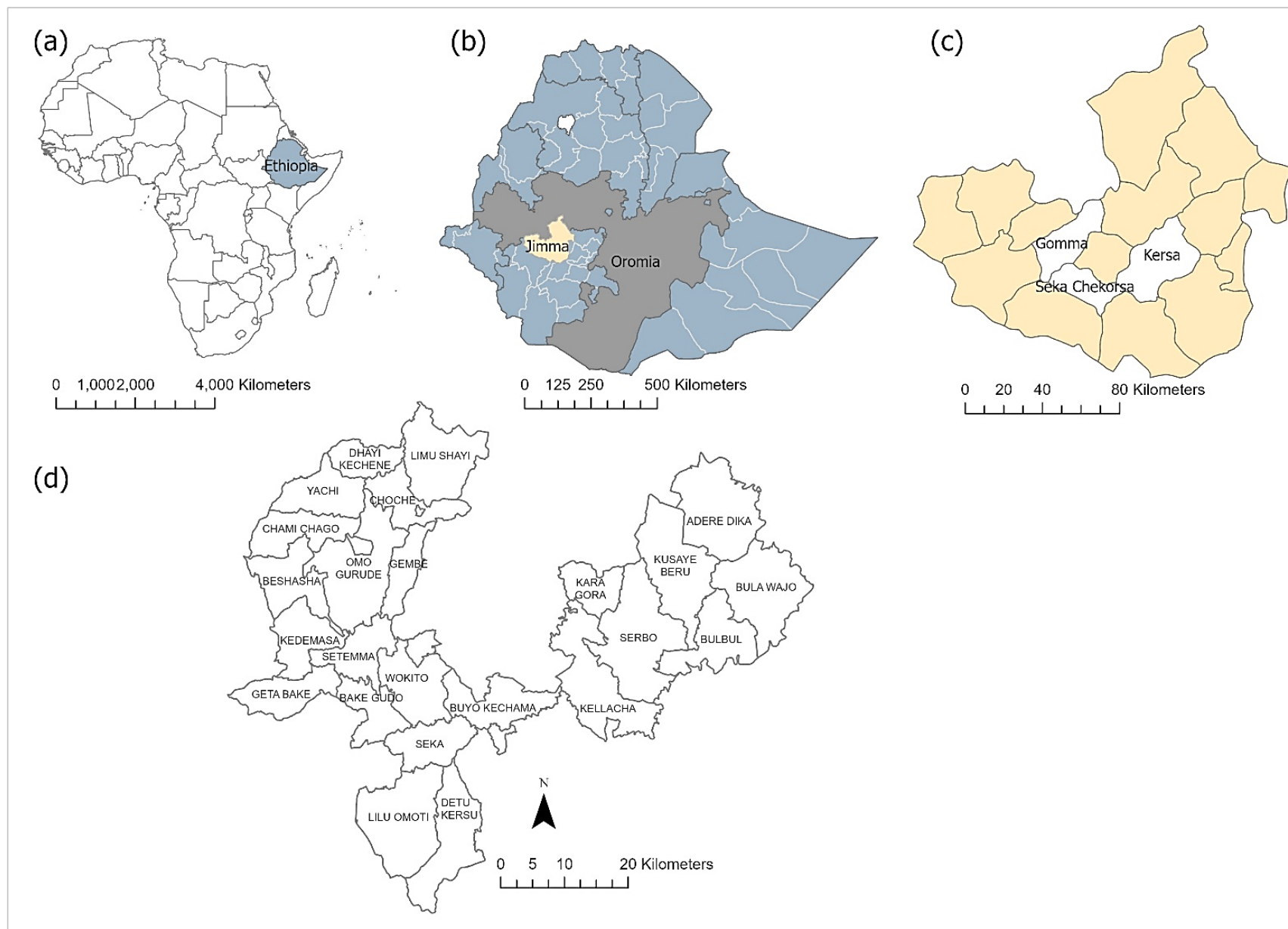


Figure3.1. Study area map showing the location of: (a) Ethiopia (b) Jimma Zone in Oromia Region (c) study districts in Jimma Zone and (d) PHCUs in study districts. Maps created in ArcGIS Pro (ESRI, Redlands, USA) Shape file for Africa obtained from OpenAfrica (4). Administrative boundary shape files for region, zone, districts and PHCUs obtained from Jimma Zone Health Office.

In 2018, Ethiopia's Human Development Index (HDI)² was 0.470 and its inequality-adjusted HDI was 0.337, placing it among the countries with low human development and below the average for Sub-Saharan Africa (HDI=0.541; inequality-adjusted HDI=0.376). Nevertheless, Ethiopia has shown improvements in development since 2000 when its HDI was 0.283; the 28% difference between the HDI and the inequality-adjusted HDI is indicative of the uneven distribution of progress across the population.⁽⁵⁾ While Ethiopia has one of the highest GDP growth rates in Sub-Saharan Africa, the World Bank lists "limited competitiveness....an underdeveloped private sector....and political disruptions associated with social unrest..." as the main threats to stable economic growth and poverty reduction.⁽¹⁾

3.1.2. Profile of Oromia region, Jimma Zone and the study districts

During the early 1990s, the country underwent decentralization and regions were established, which in turn created zones to assist in management of *woredas* (districts). Regions were legislated to handle social and economic development and oversee service delivery.⁽⁶⁾ In 2002, further decentralization transferred responsibilities of social service delivery to *woredas*.

Oromia, one of the nine regions in Ethiopia, is the largest (34% of land in Ethiopia) and most populated region in the country (37% of total population). It is divided into 20 administrative zones, of which Jimma Zone is one.⁽⁷⁾ The highlands are occupied by agriculture- and livestock-producing, sedentary communities, whereas lowlands are inhabited by pastoralist communities largely dependent on livestock production.⁽⁷⁾

As shown in Table 3.1, the proportion of women with no education and no employment is slightly above the national average, and at higher levels than men. The majority of men in Oromia engage in agricultural activities. Similar to the rest of Ethiopia, Oromia region's population is rural with limited access to mobile telephones and internet; this is especially true for women (Table 3.1).⁽³⁾

Jimma town, the administrative capital of Jimma Zone, is located about 350 kilometres (km) from the capital, Addis Ababa. Jimma Zone has 19 districts. Cereals, pulses and coffee are grown in

² The HDI is a composite index used to measure development that combines life expectancy (health), years of schooling (education) and Gross National Income per capita (income/standard of living). The inequality adjustment to the HDI assigns a penalty (using the Atkinson index) to the HDI based on inequalities in each of the component dimensions.

Table 3.1. Socio-demographic characteristics of women and men in Oromia region compared to the urban capital (Addis Ababa) and national averages

Characteristic	Oromia	Addis Ababa	Ethiopia
No education			
Women (15-49 years)	51%	9%	48%
Men (15 – 49 years)	27%	4%	28%
Literate			
Women (15-49 years)	37%	88%	42%
Men (15 – 49 years)	69%	96%	69%
Unemployed			
Women (15-49 years)	54%	35%	50%
Men (15 – 49 years)	5%	14%	8%
Agriculture occupation			
Women (15-49 years)	41%	1%	42%
Men (15 – 49 years)	79%	2%	71%
Mobile phone ownership			
Women (15-49 years)	23%	87%	27%
Men (15 – 49 years)	54%	94%	55%
Internet use			
Women (15-49 years)	3%	33%	5%
Men (15 – 49 years)	12%	60%	13%

Source: Ethiopia Demographic & Health Survey, 2016(3)

Jimma Zone in addition to various fruits and vegetables. The study districts of Gomma, Kersa and Seka Chekorsa have their capital towns located at Agaro, Serbo and Seka, respectively; these towns are also where the *Woreda* Health Offices are located. Gomma is recognized as a coffee-producing district and coffee, an export cash crop, represents an important source of income for smallholder farmers in the area.(8,9) According to a 2019 USDA report, coffee exports constituted about a third of the value of all exports in Ethiopia in 2017/2018.(10)

The road density in the three districts is quite low, ranging from 0.05 km/km² to 0.15km/km². A small airport is located in Jimma town. Seka Chekorsa has the largest land area among the three study districts.(11) According to Jimma Zone Health Office records, the number of households in the three study districts ranged between 50,000 to 60,000 and *kebeles* roughly comprised 1,400 households (Table 3.2).(12)

Table 3.2. Characteristics of study districts in February 2016 prior to baseline survey

	Gomma	Kersa	Seka Chekorsa
Number of households	56,683	43,856	52,327
Number of women	60,211	46,586	55,584
Number of <i>kebeles</i>	39	31	39
Number of health centres	10	7	9

Source: Jimma Zone Health Office report, February 2016

3.2. Evaluation of complex interventions

Complex interventions typically comprise several elements that interact with one another as well as the context within which they are embedded.(13) They often have several non-linear outcomes as a result of targeting complicated issues with long causal chains.(14–16) Complex interventions, such as MWHs, can involve a diversity of organizations and an assortment of actors (such as health workers, local leaders) frequently requiring intervention targets to perform complicated tasks. (13) These elements all act as sources of complexity.(17) In addition to knowing if a complex intervention works (effectiveness), understanding the mechanism through which it operates (how it works) and how effectiveness may change across different population subgroups (for whom it works) and settings (under what conditions it works) over time is equally important.(18,19)³

The suitability of clinical trials (sometimes referred to as explanatory trials) for evaluating complex intervention effectiveness has been questioned. One of the main concerns is how useful evidence of effect generated under highly regulated trial setting is, particularly when there is a need to replicate interventions under routine care.(16) Explanatory trials are usually designed to evaluate the efficacy of interventions i.e., their effect on outcomes under tightly controlled conditions. They commonly recruit relatively homogenous individuals, expected to have high compliance and to likely to demonstrate the highest benefit from the intervention.(20) Pragmatic trials, on the other hand, adopt broader eligibility criteria to ensure that participants are more representative of the population targeted for inference. In this way, they accord equal importance to both internal and external validity.(20) In pragmatic trials interventions are usually tested against usual care rather than the absence of any interventions. Pragmatic trials also acknowledge that blinding participants and providers may not be possible; however, blinding of outcome assessors and analysts can minimize the chances of detection bias which is important.(21) The aim of pragmatic trials is often to assist providers select between care options. They recognize that factors such as the acceptability of interventions will affect participant adherence and thus interpret trial results as the effect of *offering* interventions.(21)

³ It is important to note once again that this thesis research was nested within a larger mixed methods implementation study that examined several dimensions of the intervention components including how they were delivered across various settings and how they were expected to lead to outcomes through several intermediate outcomes such as changes in the knowledge, attitudes and practices of a diverse range of stakeholders (how do they work and under what conditions do they work?). These elements of intervention assessment fall under the primary research of other students on the project who are using qualitative and monitoring data in addition to survey data to answer some of these questions. Under my thesis objective three, the cluster RCT served as the platform to evaluate intervention effectiveness to answer the question “Do the interventions work?”

Trials are sometimes regarded as being at odds with complex interventions because they are believed to require strict standardization. This is viewed as incompatible with complex interventions which rely on flexibility for their successful integration into different settings. However, it has been noted that it is the *mechanisms* through which they are hypothesized to lead to outcomes that need to be uniform rather than the specific modalities of intervention activities.(22) For instance, in the Safe Motherhood project, one of the mechanisms for improving use of maternal health services was through increased awareness of the importance and availability of these services among families. Leaders opted for a diverse range of activities to achieve this ranging from providing information after prayer services to holding community meetings to visiting homes. Pragmatic trials are, thus, structured to support evaluation of complex interventions while preserving the benefits that randomization offers in terms of causal attribution of effects.

3.3. Sample size calculations for the cluster-randomized control trial

3.3.1. The need for cluster adjustments in sample size

Clusters are often randomized instead of individuals when interventions are delivered at this level, as was the case in our trial (Figure 3.2); a desire to reduce contamination between arms, improve compliance to arm assignments, save costs and improve generalizability are also reasons for adopting

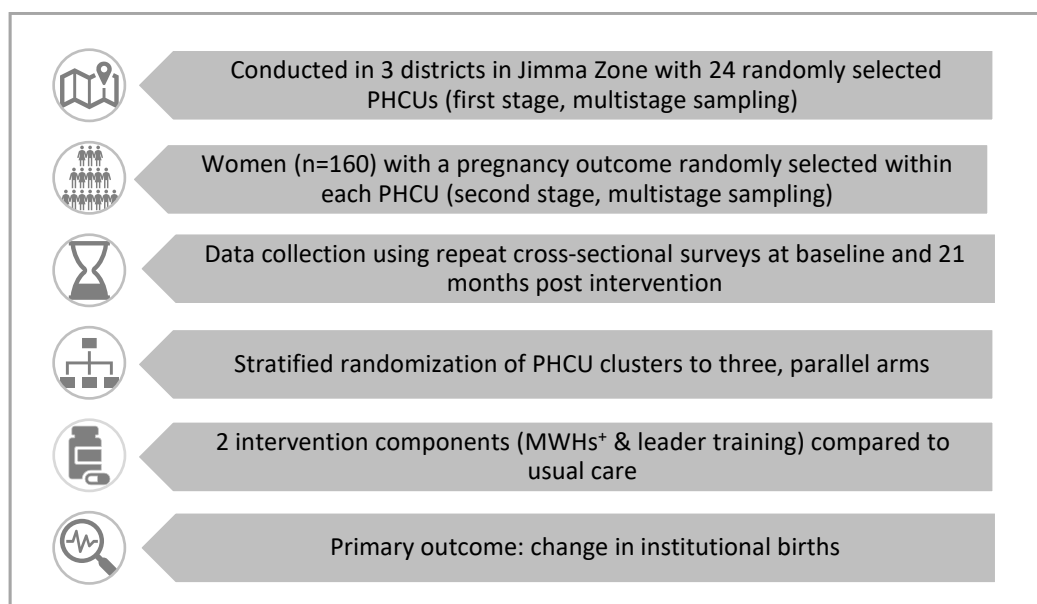


Figure 3.2. Fundamental elements of our trial design⁴

⁴ Additional details about trial design and methodology can also be found in the trial protocol paper published in Trials and included in Appendix 3.2.

this design.(23) However, cluster-randomization can be resource-intensive because there is loss in the information contributed by individuals. Due to the homogeneity in responses within clusters, higher sample sizes are required for cluster-randomized than individual-randomized trial designs.(24) Variability between clusters can also be as a result of different contextual factors or differences arising from variable levels of interaction between cluster members that affects behaviours; the higher the cluster variability, the smaller the effective sample size and the lower the precision in effect estimation.(25)

Failure to adjust sample size calculations for clustering compromises the internal validity of the trial, but has been reported to frequently occur.(26) An inappropriately estimated sample size may lack the necessary power to detect differences between trial groups, as the presence of clustering decreases the effective sample size. Sample sizes calculated under individual randomized designs need to be inflated by a factor (the design effect) to achieve comparable statistical efficiency.(25) The use of repeated cross-sections, as was the case in our trial, introduces further clustering at a temporal level, i.e. similarity in responses between individuals in the same cluster taken within the same time period (27,28) which also needs to be accounted for.

3.3.2. Method used to calculate the sample size for the cluster-randomized trial

The methods described by Hooper and Bourke (29) were followed to account for both within-period and between-period intra-cluster correlations (ICCs). As shown in Figure 3.3, the process first entails calculating the sample size required under an individually-randomized design. This number is then inflated by the product of the design effect due to cluster randomization (d_c) and the design effect due to use of repeated cross-sections (d_r).

Since the total number of available PHCUs (trial clusters) was fixed, we varied the cluster size to attain the desired power of 80% using eight clusters per arm. We used a cluster autocorrelation (π) of 0.8, also used by Hooper and Bourke.(29) This assumes a 20% decay in the correlation between responses from women within the same PHCU over time and was used in the absence of empirical evidence as it seemed to be a reasonable assumption.

To account for multiple testing, we applied a Bonferroni correction when calculating the sample size required under individual randomization. A correction was required because of the use of a shared control between the two intervention arms resulting in multiple hypothesis testing, i.e., the MWH⁺ & training arm versus control and, the training-arm versus control. Applying correction methods helps to

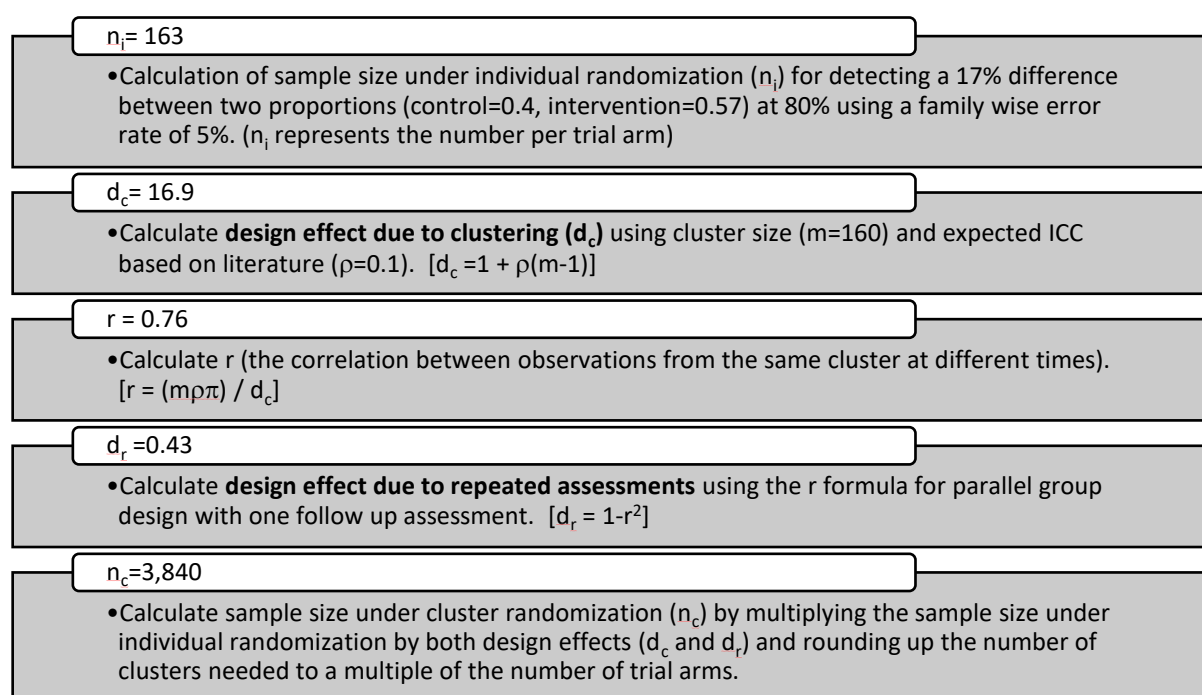


Figure 3.3. Flow chart of sample size calculations using Hooper & Bourke methodology (19)

ensure that the family-wise error rate, which is the probability of making at least one type-I error, was fixed at the desired level of 0.05.(30) The Bonferroni correction is the simplest and most commonly used correction method; the significance level of each individual hypothesis is adjusted by dividing it by the number of hypotheses tested. In the main analysis I made two comparisons and, therefore, each hypothesis was tested at 0.025. Despite its simplicity, the Bonferroni performs relative well compared to other adjustment methods and is recommended for use when performing sample size calculations.(31)

Donner & Klar also recommend performing sensitivity analyses to examine how varying the number of individuals sampled per cluster changes with different expected ICCs if a fixed number of clusters are available.(25) I, therefore, calculated the number of clusters needed using a variety of cluster sizes using two ICCs (0.10 and 0.15) obtained from a paper reporting ICCs obtained from community-based, cluster-randomized trials conducted in low resource settings.(32) Pagel and colleagues calculated ICCs between 0.03 (India) and 0.15 (Malawi) for the outcome of institutional birth.(32) An ICC of 0.1 was selected for our trial because it was above the midpoint of the range of ICCs and closer to the range reported in Malawi.

Table 3.3. Sensitivity analysis of sample size calculations

Cluster size (m)	ICC (ρ)	Cluster design effect (d_c)	Period design effect (d_t)	Number of clusters	Total sample size
100	0.10	10.9	0.46	27	2,700
120	0.10	12.9	0.45	24	2,880
160	0.10	16.9	0.43	24	3,840
180	0.10	18.9	0.42	24	4,320
200	0.10	20.9	0.41	21	4,200
250	0.10	25.9	0.40	21	5,250
100	0.15	15.9	0.43	33	3,300
250	0.15	38.9	0.39	30	7,500

A cluster size of 160 was selected instead of 120 to accommodate variable recruitment and losses due to non-response. The final selected sample size (highlighted in grey in Table 3.3) was also chosen to balance logistical and budgetary constraints with considerations of power.

3.4. Household survey questionnaire design and data collection

3.4.1. Survey tool design and programming

3.4.1.1. Household survey design

I began developing the household survey tools in October 2015⁵. These were refined over the course of one year through consultation between research partners at Jimma University and eventual pilot testing. Several questions from the Demographic and Health Survey (DHS) Program's Woman and Household questionnaires were incorporated into the demographics, information sources, and maternal health care service use modules of the household surveys⁶. A copy of the women's questionnaire is included as supplementary material in the published trial results paper (Chapter 7). A table listing the source of adapted questions is included in Appendix 3.3.

The DHS program has been in operation since 1984 and has conducted nationally representative household surveys using questionnaires in over 90 countries including Ethiopia.(33) The purpose of the questionnaires is to produce data that is comparable across countries. Survey validity and reliability has been reported to be assessed through pre-test reports, fieldworker debriefs, and the use of 'field check'

⁵ Dr. Muluemebet Wordofa from Jimma University had put together a proposed set of questions which I used as a starting point.

⁶ The questions for the survey module on social support were put together by Abebe Mamo, a Jimma University PhD student on the research team, as part of his doctoral research work. The quality of life question module was sourced from the Euro QoL EQ-5D-3L Health Questionnaire(96) as part of the cost-effectiveness analysis work planned under another Jimma University student's research.

tables.(34) While no formal validation studies were found, a DHS report on the quality of health and nutrition data examined the proportion of missing data as one of the data quality indicators and found to be less than one percent for the maternity care use questions.(35) The DHS questions were, therefore, considered to provide reliable measures of the desired indicators in our study.

I adapted questions about danger sign knowledge, birth preparedness, attitudes and perceptions around health facilities and serious health problems from the JHPIEGO Birth Preparedness and Complication Readiness (BPCR) indicator tool kit.(36) The questions around MWH awareness and experience were crafted based on the overall trial and my specific research objectives, as at the time of question development I found no validated questions. The questionnaire was translated into local languages (Afaan Oromo and Amharic) by native speakers from Jimma University and pilot tested prior to the baseline survey to modify questions that were unclear and to expand response options.

3.4.1.2. Programming of survey tools

Once the surveys were approved by the project investigators, I programmed them onto tablet computers using Open Data Kit (ODK)(37). The main advantages of using electronic surveys is the ability to program questions with required responses which helps to minimize missing data. Additionally, the inclusion of range checks on numeric variable such as age helps to prevent typographical and logic errors. I also programmed skip patterns to ensure that the correct suite of questions was administered to women depending on their responses to previous questions.

I also designed several trial process forms including ones for women replacement, refusal and follow-up visits. The replacement form was used to track information about women deemed to be ineligible. These forms, completed on tablet computers by the Jimma University PhD students who functioned as field supervisors, recorded reasons for ineligibility selected from pre-loaded options. Acceptable reasons for replacement included woman ineligibility (i.e., no pregnancy outcome within the 12-month period prior to the survey), woman listed did not live in the study area, woman was reported to be dead or the woman was away and not expected to return for more than two months. Supervisors provided data collectors with replacements from the list of randomly pre-selected women that was provided to them at the beginning of the survey. This process was put in place to avoid using a convenience replacement strategy, which would compromise the random selection process.

Refusals forms were completed by data collectors for women who did not wish to take part in the study. The district and *kebele* of residence as well as the reason for refusal were recorded on the forms that were pre-loaded on the interviewers' tablets. If the woman was willing to provide some

demographic information (age, education level, occupation, marital status and outcome of last pregnancy), this was also entered into the refusal form.

The follow-up visit form was completed by data collectors to ensure that they went back at least two additional times to households where eligible women were unavailable during initial visits. This was to avoid introducing selection bias by only enrolling women who were available for an interview when the team first visited their homes.

3.4.2. Interviewer training

Prior to commencement of baseline data collection in 2016, data collectors attended a six-day training workshop held at Jimma University. Data collectors were provided with a brief overview of the study (without details about study hypotheses), consent procedures and interview techniques by the study investigators⁷. I then conducted detailed sessions to familiarize data collectors with the women's and men's questionnaires, the use of tablet computers to administer the study surveys and the strategies to preserve data quality. The training included role plays and interview practice sessions as well as a field test to help familiarize teams with the instruments and the data collection process. I provided data collectors with key message handouts at the end of each day to highlight important aspects of the training. Prior to the endline survey in 2019, I conducted a two-day train-the-trainer session for the Jimma University PhD students leading the data collector training that year. Training materials developed for the baseline survey were used during the endline training sessions to ensure consistency between the two survey rounds.

3.5. Random selection of eligible women⁸

3.5.1.1. *Baseline household survey*

In September 2016, once complete lists for the three districts had been obtained, they were cleaned by removing any duplicated women and standardizing *kebele* and health centre spellings. Women who had delivered their last child more than 12 months before the expected start date of the baseline survey (10th October 2016) were considered ineligible and removed from the sampling frame prior to selection. Clean lists of women for each health centre catchment area were imported into

⁷ On the first day, the study and its objectives were introduced by Mr. Lakew Abebe (Jimma University) and Dr. Manisha Kulkarni (University of Ottawa), consent processes were discussed by Dr. Kulkarni and, Dr. Muluemebet Wordofa (Jimma University) spoke about good interview techniques.

⁸ The random selection of women for the baseline survey was performed by Dr. Kulkarni and demonstrated to me. In 2019, I was then able to lead the selection process for the endline survey.

STATA 14 (College Station, Texas, StataCorp LLC) and random numbers generated for each woman. Women were then ranked by random numbers and the first 160 selected from each health centre catchment to meet sample size requirements. An additional 40 women (ranked 161 to 200) were selected as replacements for women who may be found to be ineligible during the screening process.

3.5.1.2. *Endline household survey*

In March 2019, I cleaned the lists of pregnant women obtained from Health Extension Workers (HEWs) as described for the baseline survey. I removed records of women who had delivered their last child more than 12 months prior to the expected start date of the endline survey (1st April 2019) from the sampling frame prior to selection. Using the random number generator in STATA 16 (College Station, Texas, StataCorp LLC), I selected 160 women for each health centre catchment area (cluster). Similar to baseline, I created replacements lists with additional women.

3.6. **The MWH⁺ intervention component**

Two main intervention components were assessed under trial settings: (i) upgraded MWHs and, (ii) the training of local leaders (HEWs, religious leaders, and members of both the Women's and Men's Development Armies) to engage the community in making motherhood safer.⁹ The overarching aim of the MWH⁺ intervention component was to tackle physical accessibility barriers that contribute to the second delay in the "Three Delays Model"; these mainly deal with factors that prevent women from reaching health facilities in a timely manner once they have decided to seek care.(38)

3.6.1. Development process

The MWH⁺ intervention component development process followed a non-linear, iterative process comprising four main elements: (i) review of literature about quality and service-related factors influencing MWH use; (ii) consultations with maternal and child health specialists at the Jimma Zone Health Office mandated to plan and supervise implementation of policies formulated at the national level (this was done to reach consensus on the upgrades needed that would improve MWH use and to ensure alignment with national policy to support sustainable scale-up and scale-out); (iii) a rapid needs

⁹ Intervention development was led by two working groups within the research team; development of the upgraded MWHs (MWH⁺) was conducted as part of my thesis-related activities and is described in this section. Given that the interventions aim to function together to improve women's abilities to access maternal healthcare services, there is some overlap in the development process of the two intervention components; however, details pertaining to the leader training intervention development are covered elsewhere as they fall under the scope of other students' research.

assessment of existing MWHs in the study area¹⁰, and (iv) formative qualitative research to understand what quality improvements would be important to women.¹¹

As described in the previous chapter, MWH services have been available in Ethiopia for almost fifty years (39), but have only recently been formally integrated into the national primary care system.(40–42) A national assessment conducted in 2016 suggested that use was much lower than capacity, particularly in public facilities.(40) Dissatisfaction with quality of conditions and services at MWHs (43) has been suggested to be partially responsible for lower use.(44) Examples of poor conditions include inadequate beds and bedding (45–48), lack of cooking space suitably equipped with utensils (45,46,48–50), absence of clean toilets and bathing areas (47,49,51,52), difficulty in accessing clean water (46,47,49,50,53) and poor or no sources of lighting.(48,49,53) Positive perceptions about levels of comfort and pleasant experiences expected at MWHs have been correlated with intention to use MWHs in Ethiopia.(54) The MWH⁺ intervention component, therefore, entailed upgrading existing MWHs to include basic services and amenities to make them comfortable spaces for women; upgrades aimed to bring MWHs to functional levels as outlined in the national policy (41) and as assessed using the Ethiopian Federal Ministry of Health indicators of MWH functionality.¹²

The TIDieR checklist for intervention reporting was used as a guide for describing the MWH intervention below.(55) The checklist consists of 12 items which include the goal of the intervention, materials provided to participants or used in intervention delivery, intervention activities, intervention providers, modes of intervention delivery, locations where interventions were delivered, duration or

10 I created the tools intended for use by the study coordinator during visits to study sites and also visited several sites to test out the tools myself. The main goal of the need's assessment was to determine the status of existing MWHs and briefly understand how they were used and managed. The tools were designed to capture information about the availability of ANC, delivery and PNC records, the health centre's basic emergency obstetric care capacity, MWH referral criteria use and MWH use (monthly averages and duration of stay). Descriptions of available infrastructure, amenities and services provided to MWH users was also included. The site visits were also an opportunity to plan data collection logistics and checklist was created to capture information about the quality of mobile phone reception, GPS signals, travel times between health centres and the university, travel time to nearest town, road conditions, availability of village guides, etc.

11 Unavoidable delays in access to complete qualitative and implementation data as well as concerns about potential overlap in research scope of other team members led to the decision to exclude work on MWH intervention development and fidelity assessments as an objective from my main thesis work. However, some information, based on initial work that I did, is provided here as contextual background.

12 The eleven functionality indicators include: (i) spaces to accommodate women and facilitate examination of users by midwives, (ii) kitchen with a chimney and utensils, (iii) beds and bedding (for at least 10 women) (iv) availability of food and drinks, (v) services to create a home-like environment (ex: coffee ceremony), (vi) delivery care with a skilled birth attendant, (vii) presence of an attendant for cleaning, (viii) clean water supply, (ix) bathing area, (x) electricity supply, and (xi) latrine facilities.(97)

frequency of intervention delivery, modifications that occurred and how well the intervention was delivered and/or adhered to.(55)

3.6.1.1. Goals of the MWH⁺ and hypothesized mechanism of impact

The goals of the MWH⁺ component were to improve the quality of accommodation services, to enhance the monitoring of MWH users and, to improve links to delivery care at the health centres to which MWHs were attached. The upgrades were hypothesized to lead to improved perceptions around MWH quality and, through increased referrals (based on need), to result in increased MWH⁺ use ultimately leading to higher institutional births in intervention areas as more pregnant women accessed health centres for delivery. Depending on women's antenatal and postnatal length of stay at the MWH⁺, increases in the number of ANC contacts and having at least one PNC contact (within the first 48 hours of birth) were also expected to be registered.

The MWH⁺ component was complemented by the leader training, the demand-generating intervention component, which was expected to improve awareness about the importance of maternal healthcare services, including the use of delivery care at health facilities and how MWHs could facilitate access to care among leaders. Through the activities leaders were expected to organize, improvements in awareness of the importance of maternal healthcare service was also expected within the community; leaders' activities were also expected to improve community and family support for service use, thus leading to increased use of delivery care services (through MWHs or directly depending on women's needs). The leader training component also aimed to improve the linking of women to MWHs via the community-based referral system through its inclusion of HEWs and the Women's Development Army (WDA). Finally, the leader training component aimed to create an enabling environment in the community by encouraging leaders to identify problems and find locally-suited solutions to issues experienced by women trying to access maternal healthcare services. This component, through active engagement with key decision-makers and community gatekeepers also aimed to catalyse increases in community contributions (e.g., financial and material) that are pivotal in supporting MWHs in Ethiopia. Increased contributions were expected to assist with improving and maintaining the quality of services and availability of food at the MWHs, thus encouraging their use.

3.6.1.2. Intervention content

Broad categories of essential MWH elements were identified based on the World Health Organization framework for health system building blocks, which includes service delivery, health workforce, information, medical products and technology, financing and leadership as core foundations for an effective health system.(56)

As shown in Figure 3.4, core elements of MWHs⁺ include provision of health and accommodation services, availability of amenities to support accommodation and monitoring of users, staff to support

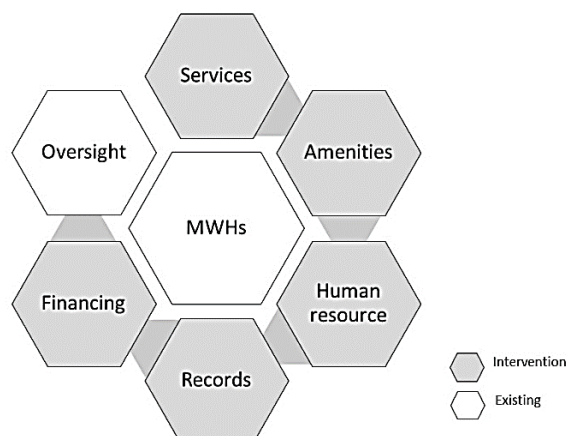


Figure 3.4. Framework of the essential elements of the MWH based on the World Health Organization health system building blocks

accommodation and access to delivery care services, records to track users, funding sources to support operations and maintenance and appropriate oversight.

3.6.1.2.1. Accommodation

Specific items required to meet these essential requirements are listed in Table 3.4. Due to resource constraints and restrictions on the allocation of research grant funds, the construction of MWH infrastructure (rooms, toilets, bathrooms and kitchens) was not possible. Therefore, improvements were made to existing structures to support comfortable accommodation by providing bedding (mattresses, pillows, blankets, sheet sets), hygiene and sanitation items (towels, slippers, buckets, sanitary pads and soap), utensils and cooking essentials (glasses, water jug, water purifier, plates, pots and pans¹³ and cooking stove with chimney), cleaning supplies (washing detergent, mop, broom, buckets, cleaning products) and items for the traditional *buna* (coffee) ceremony needed to replicate a home-like environment (electric coffee grinder, traditional coffee pot and cups). A water storage tank (1000 litres) and solar lamps were also provided to facilities with no clean water storage sources and no generator. Finally, a soft towel-like sheet was provided to mothers to wrap their newborns in recognition of the fact that baby clothes are a source of discomfort for women who cannot afford them and also represent

¹³ An *injera* bread preparing pan and stove were specifically included in the list of kitchen essentials as this bread is a staple in local meals.

an important indirect cost of delivery care use.(46,49,57) A selection of photographs from MWH⁺s can be found in Appendix 3.4.

Table 3.4. List of hypothesized requirements essential for a functioning MWH⁺

Accommodation	
• <u>Infrastructure</u>: user rooms, kitchen, bathroom, latrine • <u>Utilities</u>: power supply, water supply • <u>Kitchen</u>: stove and utensils, food supplies	• <u>Sleeping facilities</u>: linen, mattresses • <u>Hygiene maintenance</u>: cleaning supplies, toiletries, towels • <u>Home-like environment</u>: coffee ceremony essentials (<i>Ethiopian context</i>)
Services	
• <u>Health checks</u>: physical examination, vital signs monitoring • <u>Health education</u>: counselling and health information materials	• Labour room transfer: for delivery • <u>Transfer for specialised services</u>: ambulance for transfer of complicated cases to higher level facility • <u>Housekeeping services</u>: attendant to assist with cleaning
Community linkage	
• <u>Community awareness</u>: information on available services and need for support • <u>Identification</u>: eligible pregnant women, birth preparedness planning	• <u>MWH referral</u>: of eligible women to link them to service • <u>Follow up</u>: of those who have been referred and for postnatal care
Records & Management	
• <u>User records</u>: MWH register, referral cards, link to health facility records • <u>Daily operations</u>: attendant for cooking, cleaning, washing, etc	• <u>Community contributions</u>: to solicit support, manage funds • <u>Oversight</u>: manage funds/purchase, monitor service quality, coordinate link with health facility and community

Provision of food supplies was not included as part of intervention activities to avoid disruption of an existing community mechanism whereby households contribute cash and crops to fund purchasing of MWH supplies including food. The needs assessment identified the primary challenge faced by MWHs in terms of food provision was the instability in contributions due to the seasonal nature of harvests and the dwindling of supplies, particularly at the end of the financial year. Since community contributions were used to finance most MWH-related costs (apart from payment of utility bills, which

falls under the health centre's budget), the provision of accommodation supplies as part of MWH⁺ was expected to increase the proportion of contributions available for food purchase.

The suggestion to purchase televisions for MWHs⁺ was ultimately decided against to prioritize and keep costs reasonable. Moreover, while many health centres are connected to the national electricity grid, supply was erratic and unreliable, meaning television use would unlikely be possible for a significant part of a user's stay. An emphasis was, therefore, placed on HEWs, health centre staff and communities considering activities that would facilitate peer learning and support among pregnant women.

3.6.1.2.2. Services, records and management

An MWH attendant was engaged as part of MWH⁺ to help ensure that the MWH spaces and latrines were kept clean and tidy for users. The attendant was expected to help with washing dishes and MWH linen, to assist users with cooking if needed and to coordinate with the health centre director or midwife to replenish supplies at the MWH. Attendant duties also included welcoming new users, providing them with a pair of slippers, soap, the baby wrap, feminine hygiene products and a towel as well as orienting them to facilities and services available for their stay.

In terms of health services, midwives responsible for ANC services were expected to monitor the health and well-being of users through daily rounds, record their stay in the register (which was co-designed with the Jimma Zonal Health Office as part of the trial) and assist with coordinating transfer of women in labour to the delivery room. In line with national policy, MWH users were also expected to attend routine ANC checks offered at the health centre. The midwife, in collaboration with the health centre director, was expected to handle day-to-day management of the MWH. Each health centre has a committee with *kebele* representatives as members, and to which the health centre is accountable. This includes issues related to management of MWH funds/contributions and operations.

3.6.1.2.3. Community linkage and referral criteria

As outlined in the 1996 World Health Organization guide, ensuring that MWHs have a strong link to the community is essential for connecting women to the services as well as maintaining acceptability and optimum levels of use.⁽⁵⁸⁾ As part of their routine responsibilities of identifying and referring women for ANC, HEWs were expected to sensitize women about MWHs and recommend their use. ANC nurses/midwives were also expected to assess pregnant women and refer them for MWH use as required. These health workers also attend pregnant women conferences, which are monthly

group sessions organized for pregnant women at the *kebele* level by HEWs.(59) The midwife or ANC nurse from the catchment's health centre is usually invited to speak to women about topics such as danger signs or the importance of delivering at health facilities.

The leader training component also complemented efforts by HEWs and health workers to link women to MWHs through activities to increase community awareness about these services. For instance, as part of their intervention activities religious leaders committed to devoting time after prayer services to discuss the importance of MWHs with their congregation. They also volunteered to attend any community activities organized by HEWs and the WDA to promote use of delivery care and MWH services.

The MWH admission criteria described in the 2015 Ethiopian national guidelines on MWHs (41) include physical accessibility-related criteria, such as women living in distant localities or those that are inaccessible by ambulance. Women with accessibility issues are encouraged to stay at the MWH after 37 weeks of pregnancy, but cannot stay for more than four weeks. Up to 24 hours of postnatal stay is also permitted. The guidelines also advise against housing women who have had caesarean sections, have high blood pressure, have multiple pregnancies, have underlying health conditions (such as asthma, diabetes), have premature rupture of membranes, have any infection, are experiencing bleeding, or report reduced foetal movement.(41)

3.6.1.3. *MWH⁺ providers*

Roles and responsibilities of various levels of administration outlined in the 2015 MWH guideline document (41) were maintained as part of the MWH⁺ intervention. As illustrated in Figure 3.5, responsibilities around policy formulation and supervision of policy implementation of MWHs in Ethiopia are restricted to higher levels of government. The *woreda* office is charged with oversight of MWH construction and to ensure that MWHs are integrated into promotion efforts at the community and health facility levels.

The health centre is expected to set up and manage the MWH, encourage the community to contribute resources and funds to maintain MWHs and to ensure that emergency transport for complicated cases is available. Health workers are expected to monitor users through daily rounds. In addition to these responsibilities, under the MWH⁺, midwives were expected to manage MWH supplies and ensure that the MWH registers were up to date. The study coordinator from Jimma University conducted several supportive supervision visits early during the initial months of the intervention roll-

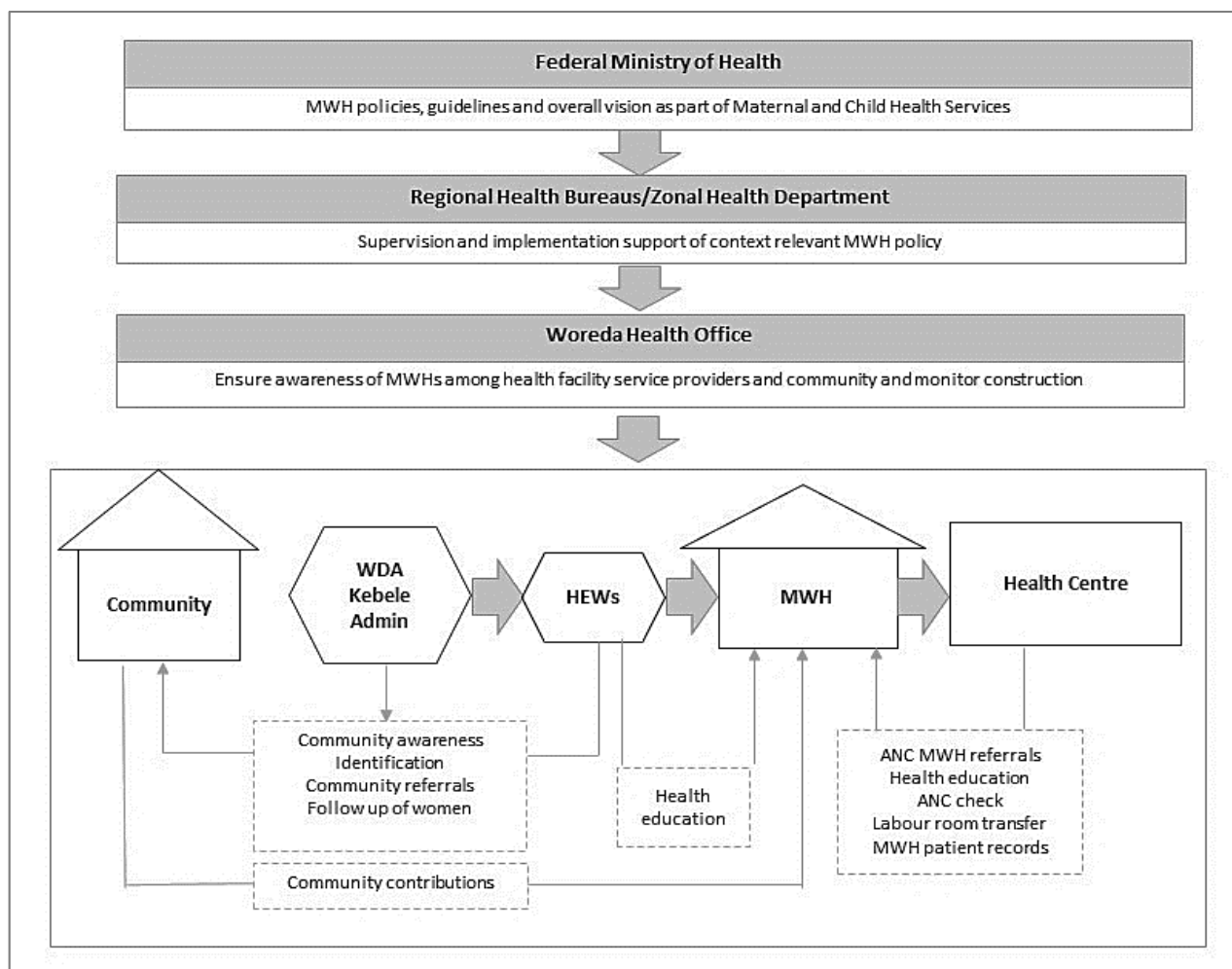


Figure 3.5. Roles and responsibilities of community and health system stakeholders in MWH implementation, outlined in the 2015 Ethiopian national MWH guidelines

out to ensure that MWHs and kitchens¹⁴ were appropriately set up and that registers were being correctly completed.

At the community level, HEWs are charged with the responsibility of identifying pregnant women, ensuring the community is aware of MWH services through activities such as pregnant women conferences and helping families with logistics of getting women to MWHs. As part of the intervention activities, HEWs also co-facilitated training workshops targeting religious and community leaders. The

¹⁴ One of the areas of support that was frequently noted by the study coordinator was the installation of the chimney in the kitchens and the setup of the *injera* preparation stove. Another was concerned the placement of the water tanks and ensuring that they were filled with water.

WDA is expected to help HEWs in reminding pregnant women who live far away or whom the ambulances cannot reach to use MWHs. Under the trial interventions, they also attended training workshops where they shared their experiences in promoting the use of maternal healthcare services, including MWHs in their communities, identified hurdles faced by women in accessing care and brainstormed potential solutions and activities that they could engage in to counter some of these issues as a group.

Religious leaders from the Muslim and Christian communities, the two main religious groups in the study area, were also intervention providers under the leader training component. Similar to WDAs, they attended training sessions, which included some guidance to identify ways in which they could promote and facilitate MWH use in their communities. In addition to discussing MWHs with their congregation and amongst fellow religious leaders, religious leaders also committed to attending Community Conversations organized by HEWs. These are similar to pregnant women conferences but open to a broader community audience, unlike pregnant women conferences, which are restricted to pregnant women. They also described jointly running some *kebele* level activities with WDAs.

3.6.1.4. MWH⁺ locations

Eight PHCUs were randomly selected for the MWH⁺ intervention located at Yachi, Chami Chago, Omo Gurude and Limu Shayi health centres in Gomma district; Lilu Omoti and Geta Bake in Seka Chekorsa district and; Kara Gora and Adere Dika in Kersa district.

3.6.1.5. Intervention tailoring

The provision of supplies to MWHs was standardized to ensure that the quality of accommodation services was comparable between all MWH⁺ sites. All sites were required to complete the MWH register to track users, and midwives and HEWs were expected to actively engage in promoting use of MWHs and referring women as needed. All MWH⁺ sites were also required to employ an attendant to maintain a pleasant and tidy living environment.

Coordination between HEWs and midwives in conducting community outreach was left to the discretion of each site. There was also some variation in the type of MWH available; Lilu Omoti and Chami Chago did not have standalone structures, but rather had designated rooms within the health centre that offered MWH services.

While accommodation of pregnant women was prioritized, no restrictions were placed on accommodating companions of pregnant women or young children as part of intervention design. However, implementation was left to the discretion of midwives and health centre directors who were responsible.

3.7. Spatial analytic methods

3.7.1. Exploratory spatial data analysis

Exploratory spatial data analysis includes descriptive and hypothesis-generating analyses conducted to gain insight into the distribution and patterns that exist in geographical data.(60) It typically involves first visualizing distributions using non-spatial tools such as choropleth maps¹⁵ and then investigating the presence of spatial autocorrelation and spatial heterogeneity. These are the principal phenomena that give rise to spatial patterns observed and that are responsible for the non-independence of spatial data.(60) Spatial heterogeneity is viewed as first-order spatial variation where differences in observations between localities is a consequence of the “changes in the underlying properties of the local environment”(61); whereas, spatial autocorrelation is an example of second-order spatial variation which is the result of “interaction effects between observations” such that the presence of an event in one location makes the occurrence in surrounding areas more likely.(61)

Spatial autocorrelation indicates the extent of spatial dependence¹⁶ that exists; it can be positive, implying that neighbouring observations are similar in value, or negative suggesting neighbouring observations are different.(62) Spatial heterogeneity refers to the variation in values of observations across space i.e. they are not homogeneous, but exhibit geographical patterns.(60) Spatial autocorrelation and heterogeneity are related and arise because locations that are close by are more likely to have commonalities than locations that are further away, often referred to as Tobler’s first law of Geography.(60)

The ultimate goal for conducting these exploratory analyses was to identify areas lagging behind in accessing maternal healthcare services to contribute to efforts to “Close the Gap”(63) and improve equity in both access to care and health outcomes.

¹⁵ Choropleth maps are thematic mapping tools that present values of an attribute associated with “aerially bounded units”(98) using colour shades or patterns to indicate values.

¹⁶ Spatial dependence refers to the fact that events, attributes or values at one location are influenced by events, attributes or values at nearby or neighbouring locations.(64)

3.7.1.1. Global spatial autocorrelation

The Global Moran's I, which I used, is considered a global test because it indicates whether or not spatial autocorrelation exists across the entire study region. The null hypothesis for the test is that there is no spatial autocorrelation and that the distribution of observed values is due to random chance. It does not provide any further information about where the spatial autocorrelation is occurring, if detected.

The Moran's I statistic describes a weighted relationship between adjacent pairs of areas. It includes a covariance term in the numerator, which quantifies the degree to which pairs of areas across the study region differ from the overall mean.(61) The index, which incorporates a spatial weights matrix, is calculated as shown below (64):

$$\text{Moran's I} = \frac{N \sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{(\sum_i \sum_j w_{ij}) \sum_i (x_i - \bar{x})^2}$$

where: N = number of observations, e.g., total number of households surveyed

$\bar{x}$ = mean of the value of variable of interest, e.g., percent ANC use in a *kebele*

x_i and x_j = the values of the variable at locations i and j

w_{ij} = weight matrix

The spatial weight matrix is an important component, because it articulates the spatial relationship hypothesized to exist between pairs of locations, and essentially defines the spatial structure under consideration. One way of conceptualizing relationships between locations, recommended for exploratory analyses, is through adjacency, which is a “binary equivalent of distance”.(62) The spatial weight matrix consists of ones and zeros indicating whether locations are neighbours or not. ArcMap (ESRI, Redlands, USA), the geographical information system (GIS) software used for exploratory analysis, offers several options to define neighbours that are based on distances or adjacency of polygons. For instance, in the Contiguity Edges and Corners conceptualization (Queen's case), *kebeles* would be considered neighbours if they shared a boundary or a node. Inverse Distance, which I selected for my analyses, gives primacy to closer than distant *kebeles* but does not require them to necessarily border or touch one another to be considered as neighbours.

The calculated Moran's I value is compared to an expected value and a Z-score and p-value are computed to determine whether spatial patterns observed are random or not. The mean and standard deviation for standardized Z-values used for significance tests can be generated through a permutation approach where data is re-sampled multiple times and an empirical distribution created, to which the

calculated index is compared.(60) Moran's I will generally fall between -1 and 1. O'Sullivan and Unwin suggest that values of Moran's I greater or equal to 0.3 or -0.3 imply strong autocorrelation.(61)

Row standardization, which is recommended when analysis involves administrative boundaries, was used. (65) This helps minimize bias due to the aggregation scheme used, which results in areas having different numbers of neighbours. Row standardization involves the use of relative weights computed by dividing each weight by the sum of weights for all neighbouring areas.(65)

3.7.1.2. Local spatial autocorrelation

Once the presence of spatial autocorrelation in the study area (global spatial autocorrelation) is established, the next logical step is to identify where significant clustering is occurring. Local statistics function by examining subsets of data near the location of interest (61) and are useful when there is an explicit interest in exploring "differences across space".(66) I used two different types of local tests: the Getis-Ord G_i^* test and the Kulldorff spatial scan statistic to explore where clustering occurred using *kebele*- and household-level data.

3.7.1.2.1. The Getis-Ord G_i^*

This statistic facilitates the detection of groups of high values (hot spots) or low values (cold spots) concentrated in certain locations in the area of interest. It represents the proportion of values in the study area that belong to the neighbours of the location of interest. Therefore, when a location is surrounded by high values the value of Getis-Ord G_i^* will be high, and low when surrounded by low values.(61)

The statistic is calculated using the following formula:(61)

$$G_i^* (d) = \frac{\sum_j w_{ij}(d)x_j}{\sum_{j=1}^n X_j}$$

where: $w_{ij}(d)$ = the weights from the spatial weights matrix

x_j = value of the observation at location j

The *Optimized Hot Spot Analysis* tool in ArcMap (ESRI, Redlands, USA) was used to identify clusters at *kebele*-level reported in Chapter 5. This tool was used instead of the conventional *Hot Spot Analysis* tool because it incorporates a feature that uses the data to determine the appropriate scale of analysis. This is suitable for use when an appropriate distance for the analysis cannot be specified. The tool employs an *Incremental Spatial Autocorrelation* strategy where distance is progressively increased

and the Z-scores generated for each distance from a Global Moran's I test are compared; the first distance at which the Z-score peaks is interpreted to be where there is highest clustering and is, therefore, used as the scale of analysis. If no distance is identified using the clustering intensity method, the average distance at which each feature has a particular number of neighbours (k) (determined based on the total number of features ($k=0.05 \times \text{total number of features}$)) is used.(65) The optimal distances identified for each service are shown in Table 3.5.

Table 3.5. Optimal distance bands calculated for each service

Service	Optimal distance band (m)
Antenatal care	10, 446
Maternity waiting homes	7,034 ¹
Delivery care	19,218
Postnatal care	7,034 ¹

¹ The clustering intensity method did not yield an optimal distance value, therefore, the average distance based on k ($k=0.05 \times 94 \sim 4$) which was found to be 7,034 metres was used.

Once distance bands are determined, the Getis Ord G_i^* test is used to determine locations of hot and cold spots. The statistic was calculated for each *kebele* and comparisons made between each *kebele* and neighbouring *kebeles*. *Kebeles* which are found to be statistically significant hot spots are those surrounded by other *kebeles* with high service use while cold spots are those *kebeles* surrounded by other *kebeles* with low service use.

The tool also incorporates adjustments for multiple testing using the False Discovery Rate method. Adjustments are needed as the chances of obtaining false positives (i.e. rejecting a null hypothesis when it is actually true, known as a Type I error) are high when several hypotheses are tested.(67) The method works by controlling the overall proportion of false positives and offers the benefit of being less conservative than the Bonferroni method, where some significant clusters can be omitted.(67) Hot and cold spots detected at the 99%, 95% and 90% confidence intervals are indicated using shades of red and blue respectively.

3.7.1.2.2. The Kulldorff spatial scan statistic

To further explore spatial variation in the study area without imposing administrative boundary constraints, which may not necessarily align with service use clusters, I used the Kulldorff spatial scan statistic with household level data (Chapter 5). The advantage of this method is that the variable scanning window size facilitates cluster detection even when cluster size is unknown.(68) This is the most commonly applied scan test and works by placing either circular or elliptical shaped windows of different sizes over the study area to identify the location and size of the most likely cluster.(69) The probability of an outcome within and outside the window are calculated for each scanning window and

likelihood values computed. The maximum likelihood is the scan statistic which is compared to a distribution generated using Monte Carlo simulations under the null hypothesis as one does not exist for the test statistic.(69,70) The null hypothesis of no difference in probability of outcomes inside and outside the window exists is tested. Likelihood values, locations and size of clusters and significance are produced as part of the output in SaTScan version 9.6 (71), the software used.

Due to the binary nature of all service outcome variables, I used a Bernoulli model. The study area was scanned for clusters with either high and low rates of service use using a circular scanning window. A limitation of this approach is that if the actual shape of clusters is not circular, important clusters may be missed. I set the window radius to an upper limit of 5km to avoid detection of clusters of very large size that do not provide useful insight into utilization patterns. I also selected this distance as it represents about a one-hour walking distance (72,73), which I hypothesize is the level at which interpersonal and social determinants of service use operate at.

3.7.2. Geographically weighted regression models

The presence of spatial autocorrelation in maternal healthcare service use would suggest that nearby localities, whether this pertains to PHCUs, *kebeles* or some other form of neighbourhood, exhibit similar patterns in service use. It is, then, reasonable to hypothesize that these localities may also be subject to specific contextual influences that give rise to different access patterns across the study area.

A fairly well-laid out process exists to explore whether or not this is the case.(61) First, residuals from conventional statistical regression models are generated and tested for the presence of a spatial autocorrelation structure using a global test such as Global Moran's I. Two options then exist; either this spatial dependence is accounted for using spatial regressions, or through models that are allowed to vary spatially i.e., geographically weighted regressions (GWRs). Spatial regression models adjust for spatial correlation structures by either addressing spatial correlation in the dependent variable (spatial lag models) or in the error term (spatial error models).(74) Spatial regression models assume that spatial dependence is homogenous across the study area and generate single parameter estimates for the entire study area (global estimates), albeit with spatial dependence incorporated.(61) Since my objective was to determine whether the relationships between explanatory variables and service outcomes varied between localities, GWRs were more appropriate. GWRs support the exploration of spatial heterogeneity, while spatial regression models adjust estimates for spatial dependence.

3.7.2.1. GWR model specification

GWRs are an extension of traditional regression models (global models)¹⁷ that generate parameter estimates for each locality of interest in the model:(75)

$$\text{Global linear regression model: } y_i = \beta_0 + \sum_k \beta_k x_{ik} + \varepsilon_i$$

where: β_0 = intercept
 β_k = parameter estimate for k explanatory factors
 ε_i = independent, random error term

$$\text{Linear GWR model: } y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

where: $\beta_0(u_i, v_i)$ = intercept at location i with coordinates (u_i, v_i)
 $\beta_k(u, v)$ is a continuous function at point i that results in a continuous surface of parameter values (66)
 ε_i = independent, random error term

Binomial geographically weighted generalized linear model:

$$\log\left(\frac{E(y_i)}{1-E(y_i)}\right) = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

where: y_i = binary outcome, e.g., ANC = yes or no
 $E(y_i)$ is the probability that $y_i=1$, e.g., ANC = yes

As part of the estimation process, beta coefficients are assumed to be functions of location and a subset of points that are close to point i are used in the regression model to obtain $\beta_k(u_i, v_i)$. This processes is repeated for every location using a different subset of nearby points to generate a continuous surface of parameter values.(75) The relative influence of observations included in local calibration model subsets is governed by a weight matrix, W , whereby points that are closer to location i are assigned higher weights. This is an important departure from conventional regression models where each observation has a constant weight ($w_i=1$) regardless of its location. The beta coefficients are estimated as follows (75):

$$\hat{\beta}(u_i, v_i) = (X^T W(u_i, v_i) X)^{-1} X^T W(u_i, v_i) y$$

¹⁷ Global models correspond to conventional statistical regression models whose parameter estimates represent the average across the entire study area.

where: $\hat{\beta}$ = an estimate of β
 $W(u_i, v_i)$ = n by n matrix with zero off-diagonals and weights in the diagonal elements for n observations in the calibration subset in relation to point i

3.7.2.2. Kernel and bandwidth selection

Weights are usually specified as continuous functions to avoid problems of discontinuity that would arise if points that were not nearby were simply excluded from local calibration subsets. Parameter estimates could dramatically change making it difficult to discern between legitimate estimates and those that were artefacts of the process.(75) Two main weighting functions (kernels) are commonly used: a Gaussian function or a bi-square function, which is Gaussian-like. Both kernels specify the “fractional” contribution to parameter estimation that observations make based on their proximity. A bi-square kernel is specified as follows (75):

$$w_{ij} = \left[1 - \left(\frac{d_{ij}}{b} \right)^2 \right]^2 \text{ if } d_{ij} < b$$

where: b = bandwidth

The choice of kernel is of less consequence than the bandwidth parameter which specifies distance decay. While larger bandwidths tend to result in local parameter estimates that approximate global estimates, smaller bandwidths have high variance as they are more sensitive to nearby observations.(75)

The density of observations across the study area also needs to be considered when specifying kernels. Unlike fixed kernels, which have a constant shape and size, adaptive kernels vary with data point density. Their bandwidths are smaller in areas of high density and larger where points are more spread out. Adaptive kernels are recommended for datasets where observation density is not uniform; they have the advantage of ensuring reasonable standard errors where data points are sparse while supporting the exploration of relationships that change across small distances where data points are densely concentrated.

Several options exist to create adaptive kernels; I used the nth nearest neighbour method, which is among the most commonly employed. The calibration of the local model involves estimating the number of data points (or nearest neighbours) that are included and the kernel determines the weight to be assigned until the nth neighbour.(75)

Bandwidths are typically selected either using cross-validation approaches¹⁸ or methods that balance goodness of fit with degrees of freedom used. The latter works by identifying the bandwidth that minimizes criteria, such as the corrected Akaike Information Criterion, as the optimal bandwidth. The processes can be automated by using optimization techniques¹⁹ such as the Golden Section search.(75)

3.7.2.3. GWRs and spatial scale

A common concern with spatial analyses is that the results may change depending on the definition of the area under study in terms of configuration (zoning effect) or size (scale effect).(75) Termed the modifiable areal unit problem (MAUP) by Openshaw in the mid-eighties (76), the core issue is that the unit of analysis may be arbitrary and have little relation to the phenomenon under investigation. For instance, enumeration areas are often used as proxies for studying community factors using DHS datasets (see Mekonnen (77) or Mezmur (78) as examples) although they were created for practical purposes of administering national census. (79)

GWRs are less susceptible to these issues because they do not rely on pre-specified, discrete units for analysis. Instead, the data are used to identify the appropriate scale of analysis using optimization procedures to select optimal bandwidths as described in earlier sections. Moreover, a “fuzzy” boundary (75) is created around each regression point to generate local estimates using subset of points designated to be neighbours. In this way a surface of estimates is generated that can be mapped to explore how associations vary across space. GWRs are also more compatible with modelling continuous processes, which natural phenomenon are more likely to be.

However, it is important to point out that classical GWR models assume that all spatial processes responsible for the local variation observed operate at the same spatial scale. This is translated into the use of a single bandwidth parameter that reflects the average spatial scale at which processes may actually be operating at.(80) However, it is plausible that certain processes may be confined to smaller scales, such as neighbourhood wards, while others may operate at a more regional level. Multi-

¹⁸ Cross-validation is a method to estimate the prediction error and functions by splitting the dataset into two to generate estimates with one part and validate predictions with the other part.(99) For bandwidth selection, this process involves the calculation of cross-validation scores that are then plotted against bandwidth to identify the bandwidth that minimizes the value of the score.(75)

¹⁹ Function minimization techniques work by iteratively evaluating three functions $f(a)$, $f(b)$ and $f(c)$ (known as the triplet) using values such that $a < b < c$ and creating new triplets until two successive functions have almost the same value. In the context of GWR, three bandwidths are selected and either cross-validation scores or cAIC compared for bandwidths that fall between the largest (a) and smallest (c) values until the optimal is identified.(75)

scale GWRs adopt an analytic framework in which optimal bandwidths for each explanatory variable are identified separately.(80) At present, though, only linear multi-scale GWRs are available as they are yet to be extended to accommodate binary outcomes.

3.7.2.4. Local multicollinearity and diagnostics

Collinearity exists when two or more variables in a regression model are “linearly related”(81) and has been described to affect parameter stability and inflate standard errors thereby rendering parameter estimates unreliable.(81) In the context of GWRs, collinearity between local estimates has been cited by Wheeler and Tiefelsdorf as a problem that can exist even if variables are not correlated at a global level.(82) Using simulations, Fotheringham and Oshan, however, demonstrate that GWRs are only susceptible to extreme cases of multicollinearity.(83) They argue that previous literature on local multicollinearity not only used sample sizes too small to support GWRs (e.g., $n=100$ locations), but also confuse the effects of spatial autocorrelation in single processes and correlation between processes with multicollinearity.(83)

Nevertheless, several measures exist which, although use arbitrary cut-offs, can point to the existence of local multicollinearity.(83) The local variance inflation factor, for instance, can be calculated for each explanatory variable using the coefficient of determination ($R^2_k(i)$) at each location (84); however, it is not helpful in identifying between which variables multicollinearity exists.(83) Variance-decomposition proportions and local condition numbers²⁰ can also be used to investigate the presence of local multicollinearity. Larger condition numbers point to stronger multicollinearity among explanatory variables with 30 often used as a critical value.(84) Variance-decomposition proportions greater than 0.5 are also suggestive of multicollinearity.(84)

3.7.2.5. Interpretation of results and test for spatial non-stationarity

Local parameter estimates generated from GWRs are usually mapped to visualize patterns. Pseudo t-tests provide an indication as to where associations worth further exploration may be present. Parameter estimates are divided by their standard deviations to compute t-values. These t-values are then compared to a critical value that is adjusted using a Bonferroni-style correction method proposed

²⁰ Both the condition number and the variance decomposition proportion are determined using the singular value decompositions of the design matrix X , which contains the explanatory variables.(83)

by Da Silva and Fotheringham (85) to account for multiple testing²¹. Without applying a correction, the risk of false positives would be high. Local parameter estimates where a large proportion exceed the critical value are likely to indicate areas that require future research into contextual influences. The Bonferroni-style correction method used is fairly conservative making it hard to reject the null hypothesis especially when large samples are used.(75)

In addition to mapping potentially interesting relationships, spatial tests for non-stationarity of parameter relationships can be performed. These tests answer the question whether the observed variations in relationships of the parameter with the outcome are greater than that which would be observed by chance. The null hypothesis for the test is that the parameter does not vary spatially i.e. is “globally fixed”.(75) A Monte Carlo approach is used to determine the distribution of the variance of the parameter. Under this method the experimental distribution is obtained by randomly transposing geographical locations and variables. The rationale for doing this is that if there were no spatial variability then any combination of locations and regression variables would be possible. The actual variance is then compared to this experimental distribution. If any of the explanatory variables are identified to be stationary, semi-parametric (mixed) models that include both globally-fixed and locally-varying parameters (75) may be necessary.

3.8. Trial analyses

3.8.1. Regression modelling

To estimate the effect of the interventions on the primary outcome of interest, institutional births, a generalized linear mixed model was used because of the binary nature of the outcome and the need to account for clustering in responses. An intention-to-treat principle was used, meaning that cluster trial arm allocations were maintained whether or not interventions were actually delivered as assigned. This preserves randomization and prevents introduction of bias at the analysis stage.(86)

The equation representing the setup of the regression model used for trial analysis is shown below (fixed effects only).

$$\text{logit}[E(Y_{ij}|b_i)] = \beta_0 + \beta_1 \text{treat}_{(\text{training only})} + \beta_2 \text{treat}_{(\text{MWH}^+ \text{ \& training})} + \beta_3 \text{time} + \beta_4 \text{MWH} + \beta_5 \text{BEmOC}$$

²¹ The proposed correction draws from the Benjamini-Hochberg False Discovery Rate and the Theory of Dependent Tests whereby the degree of dependency is computed using the effective number of parameters (p_e) estimated in the GWR, the number of locations and the number of parameters (p) in the model. The family-wise error rate is divided by the ratio of p_e to p .(85) For more details see Da Silva and Fotheringham, 2016.(85)

where:

Y_{ij} : Institutional birth	0 = No 1 = Yes
Treat: baseline constrained intervention group and measurement period	0 = control and intervention groups at baseline and control at endline 1 = Training only at endline 2 = MWH ⁺ & training at endline
Time: survey round at which outcomes were assessed	0 = baseline 1 = endline
MWH: MWH baseline functionality indicator	0 = Low functioning 1 = Higher functioning
BEmOC: Basic emergency obstetric care capacity at PHCU health centre	0 = Low capacity 1 = Higher capacity

The parameter estimate β_0 corresponds to the predicted log-odds of mean institutional births at baseline constrained to be equal across the three trial arms. β_1 is the difference in log-odds between the control and training only arms in the change from baseline to endline in institutional births and, therefore, indicates the effect of the training-only intervention on the primary outcome. β_2 is the difference between the control and MWH⁺ & training arms in the change from baseline to endline in institutional births corresponding to the MWH⁺ & training intervention effect.

Baseline outcomes were incorporated into the model using a constrained baseline approach as outlined by Hooper and colleagues.(87) There are several options in terms of handling baseline assessments: they can be ignored, used to calculate change scores, included as covariates in conditional analyses (e.g., ANCOVA) or included as part of the outcome vector.(88) Constrained baseline analysis falls under the latter, but utilizes the information that, by design, the expected difference between the trial arms at baseline is zero.(89) As per standard approaches for analysing longitudinal randomized controlled trials, the regression model includes the main effect for time and an interaction between trial arm and time (“treat” in the model described above); however, the main effect of trial arm is omitted. This term would have represented the baseline difference in the outcome between the arms. Thus, the analysis relies on the assumption that, due to randomization, there are no *systematic differences* between trial arms at baseline (87), i.e., it constrains the baseline differences to be zero. This approach has been shown to perform well in longitudinal cluster randomized trials and to retain desired power particularly when a flexible correlation structure is adopted as was done for this analysis.(87,89)

Time and stratification variables (MWH functionality and BEmOC capacity) were included as fixed effects covariates. Failure to adjust for stratification variables in analysis can result in type II errors (90) due to the overestimation of p-values and wide confidence intervals.(91)

A random intercept was used to account for within-period ICC while a random slope was included to account for the between-period ICC. A logit link function was used to relate the outcome to the linear predictor as required using the generalized linear model framework.(92) The probability distribution of the outcome was assumed to be binomial as shown below.

$$Y_{ijkt} \sim \text{Bin}(\pi_{ijkt}, 1)$$

where:

$$Y_{ijkt}$$

Institutional birth outcome of woman i ($i = 1, \dots, 160$) in PHCU j ($j = 1, \dots, 24$) and trial arm k ($k = 0$ for control, 1 for training only, 2= MWH⁺ & training) at time t ($t = 0$ for baseline, $t=1$ for endline).

$Y_{ijkt} = 1$ for women who gave birth at a health facility
 $Y_{ijkt} = 0$ for women who did not give birth at a health facility

π_{ijkt} The probability of giving birth at a health facility

In addition to specifying the linear predictor, the link function and the probability distribution for the outcome, the type of approach to modelling correlations needs to be selected. For this analysis, random effects were included in the linear predictor, referred to as “modelling with G-side effects”.(93) This involves specifying the columns of the Z matrix (94) and the structure of the variance matrix G. The Z matrix is a design matrix for random effects, similar to the X, which contains the fixed effects in the linear predictor.(92) In this model, each PHCU had three columns comprising one intercept column and two time-columns. This approach generates “subject-specific” estimates typical of conditional models. R-side modelling takes on a “population-averaged” perspective characteristic of generalized estimating equation methods.(93)

Due to the relatively small number of clusters available, the denominator degrees of freedom were calculated using the Kenward-Roger approximation. This results in the use of a precision estimator that is bias-adjusted and does not underestimate the variance.(95)

The intervention effects were estimated using SAS statistical software (SAS Institute, Cary, USA) using the LSMEANS statement, which calculated the least square means for the control, leader training intervention and the MWH⁺ & leader training intervention arms at endline through specification of “AT

time=1". The covariance estimate for the intercept that is generated corresponds to the variance of the random PHCU intercept on the logit scale.(93)

3.8.2. Estimation of intra-cluster correlation coefficient

The within-period and between-period ICCs were estimated in SAS on the proportions scale using a linear mixed effect model. The PROC MIXED command was used with time as the only fixed effect, and with random effects for cluster and cluster-time. Using the covariance parameters generated, the within-period, between-period and the cluster autocorrelation were calculated as follows:

Within-period ICC	$\frac{\text{cluster covariance} + \text{time-cluster covariance}}{\text{cluster covariance} + \text{time-cluster covariance} + \text{residual covariance}}$
Between-period ICC	$\frac{\text{cluster covariance}}{\text{cluster covariance} + \text{time-cluster covariance} + \text{residual covariance}}$
Cluster autocorrelation	$\frac{\text{between-period ICC}}{\text{within-period ICC}}$

3.9. Chapter summary

In this chapter, information pertaining to study setting, data collection tool design, MWH⁺ intervention development, trial sample size calculation and participation selection as well as spatial and regression modelling was elaborated upon to provide the necessary background to the results presented in the next few chapters. The next chapter, looks at the factors identified as important in influencing MWH use among women living in rural Ethiopia using baseline survey data from the trial.

3.10. Chapter References

1. Ethiopia - Country overview [Internet]. 2019 [cited 2019 Sep 20]. Available from: <https://www.worldbank.org/en/country/ethiopia/overview>
2. World Bank Data - Ethiopia [Internet]. [cited 2019 Sep 20]. Available from: <https://data.worldbank.org/country/ethiopia>
3. Central Statistical Agency. Ethiopia Demographic & Health Survey (2016). Addis Ababa and Rockville, Maryland; 2017.
4. OpenAfrica. Africa shapefiles [Internet]. 2020 [cited 2020 Oct 16]. Available from: <https://africaopendata.org/dataset/africa-shapefiles>
5. UNDP. Inequalities in Human Development in the 21st Century. 2019.
6. Faguet J-P, Khan Q, Kanth DP. Decentralization's effects on education and health: Evidence from Ethiopia. Washington, DC; 2019.
7. UNICEF. Situation Analysis of Children and Women: Oromia Region. 2019.
8. Diro SC, Ayele SA, Erge BE. Trends and determinants of coffee commercialization among smallholder farmers in southwest Ethiopia. *J Agric Econ Rural Dev*. 2016;3(2):112–21.
9. Diro S, Erko B, Yami M. Cost of Production of Coffee in Jimma Zone , Southwest Ethiopia. *Ethiop J Agric*. 2019;29(3):13–28.
10. Bickford R. Ethiopia Coffee Annual Report. 2019.
11. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2017.
12. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2016.
13. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: new guidance. London; 2006.
14. Munro A, Bloor M. Process evaluation: the new miracle ingredient in public health research? *Qual Res*. 2010;10(6):699–713.
15. Shiell A, Hawe P, Gold G. Complex interventions or complex systems? Implications for health economic evaluation. *Br Med J*. 2008;336:1281–3.
16. Victora CG, Habicht J-P, Bryce J. Evidence-based public health: moving beyond randomized trials. *Am J Public Health*. 2004;94(3):400–5.
17. Trompette J, Kivits J, Minary L, Alla F. Dimensions of the Complexity of Health Interventions: What Are We Talking about? A Review. *Int J Environ Res Public Health*. 2020;17(3069).
18. Mills A, Gilson L, Hanson K, Palmer N, Lagarde M. What do we mean by rigorous health-systems research? *Lancet*. 2008;372:1527–9.
19. Datta J, Petticrew M. Challenges to evaluating complex interventions: a content analysis of published papers. *BMC Public Health*. 2013;13(568).
20. Sox HC, Lewis RJ. Pragmatic Trials Practical Answers to “RealWorld” Questions. *JAMA*. 2016;316(11):1205–6.
21. Eldridge S. Pragmatic trials in primary health care: What, when and how? *Fam Pract*. 2010;27:591–2.
22. Hawe P, Shiell A, Riley T. Complex interventions: how “out of control” can a randomised controlled trial be? *Br Med J*. 2004;328:1561–3.
23. Taljaard M, Grimshaw JM. Concept, characteristics and implications of cluster randomization. *Clin Investig (Lond)*. 2014;4(1):1–4.

24. Cornfield J. Randomization by group: a formal analysis. *Am J Epidemiol.* 1978;108(2):100–2.
25. Donner A, Klar N. Design and Analysis of Cluster Randomization Trials in Health Research. New York: Wiley; 2000.
26. Eldridge S, Ashby D, Bennett C, Wakelin M, Feder G. Internal and external validity of cluster randomised trials: systematic review of recent trials. *BMJ.* 2008;
27. Kasza J, Forbes AB. Inference for the treatment effect in multiple-period cluster randomised trials when random effect correlation structure is misspecified. *Stat Methods Med Res.* 2019;28(10–11):3112–22.
28. Hemming K, Kasza J, Hooper R, Forbes A, Taljaard M. A tutorial on sample size calculation for multiple-period cluster randomized parallel, cross-over and stepped-wedge trials using the Shiny CRT Calculator. *Int J Epidemiol.* 2020;0(0):1–17.
29. Hooper R, Bourke L. Cluster randomised trials with repeated cross sections: alternatives to parallel group designs. *BMJ.* 2015;350(h2925).
30. Wason JMS, Stecher L, Mander AP. Correcting for multiple-testing in multi-arm trials: is it necessary and is it done? *Trials.* 2014;15(364).
31. Vickerstaff V, Omar RZ, Ambler G. Methods to adjust for multiple comparisons in the analysis and sample size calculation of randomised controlled trials with multiple primary outcomes. *BMC Med Res Methodol.* 2019;19(129).
32. Pagel C, Prost A, Lewycka S, Das S, Colbourn T, Mahapatra R, et al. Intraclass correlation coefficients and coefficients of variation for perinatal outcomes from five cluster-randomised controlled trials in low and middle-income countries: results and methodological implications. *Trials.* 2011;12(151).
33. The DHS Program [Internet]. [cited 2020 Feb 5]. Available from: <https://dhsprogram.com/Who-We-Are/About-Us.cfm>
34. Arnold F, Khan SM. Perspectives and implications of the Improving Coverage Measurement Core Group's validation studies for household surveys. *J Glob Health.* 2018;8(1).
35. Pullum TW. An Assessment of the quality of data on health and nutrition in the DHS surveys, 1993-2003. 2008.
36. JHPIEGO. Monitoring birth preparedness and complication readiness. Tools and indicators for maternal and newborn health. Baltimore; 2004.
37. Open Data Kit (ODK) [Internet]. [cited 2020 Aug 3]. Available from: <https://getodk.org/>
38. Thaddeus S, Maine D. Too far to walk: maternal mortality in context. *Soc Sci Med.* 1994;38(8):1091–110.
39. Vermeiden T, Schiffer R, Langhorst J, Klappe N, Asera W, Getnet G, et al. Facilitators for maternity waiting home utilisation at Attat Hospital: a mixed-methods study based on 45 years of experience. *Trop Med Int Heal.* 2018;23(12):1332–41.
40. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J.* 2012;50(3):209–19.
41. Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa; 2015.
42. Federal Democratic Republic of Ethiopia Ministry of Health. National Reproductive Health Strategy (2016-2020). Addis Ababa; 2016.
43. Penn-Kekana L, Pereira S, Hussein J, Bontogon H, Chersich M, Munjanja S, et al. Understanding the implementation of maternity waiting homes in low- and middle-income

- countries: A qualitative thematic synthesis. *BMC Pregnancy Childbirth*. 2017;17(269).
44. van Lonkhuizen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
 45. Bonawitz R, Mcglasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia : A mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS One*. 2019;14(11):e0225523.
 46. Scott NA, Vian T, Kaiser JL, Ngoma T, Mataka K, Henry EG, et al. Listening to the community:Using formative research to strengthen maternity waiting homes in Zambia. *PLoS One*. 2018;13(3).
 47. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: Women’s beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;12(61).
 48. Suwedi-Kapesa L, Nyondo-Mipando A. Assessment of the quality of care in Maternity Waiting Homes (MWHs) in Mulanje District, Malawi. *Malawi Med J*. 2018;2:103–10.
 49. Chibuye PS, Bazant ES, Wallon M, Rao N, Fruhauf T. Experiences with and expectations of maternity waiting homes in Luapula Province, Zambia: a mixed – methods, cross-sectional study with women,community groups and stakeholders. *BMC Pregnancy Childbirth*. 2018;18(42).
 50. Kebede KM, Mihrete KM. Factors influencing women’s access to the maternity waiting home in rural Southwest Ethiopia: a qualitative exploration. *BMC Pregnancy Childbirth*. 2020;20(296).
 51. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynaecol Obstet*. 2010;108:152–3.
 52. Sundu S, Mwale OG, Chirwa E. Antenatal Mothers ’ Experience of Staying in a Maternity Waiting Home at Malamulo Mission Hospital in Thyolo District Malawi : A Qualitative , Exploratory Study. *Women’s Heal Gynecol Heal Gynecol*. 2017;3(1).
 53. Lori JR, Munro-Kramer ML, Shifman J, Amarah PNM, Williams G. Patient Satisfaction With Maternity Waiting Homes in Liberia: A Case Study During the Ebola Outbreak. *J Midwifery Womens Health*. 2017;62:163–71.
 54. Endayehu M, Yitayal M, Debie A. Intentions to use maternity waiting homes and associated factors in Northwest Ethiopia. *BMC Pregnancy Childbirth*. 2020;20(281).
 55. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ*. 2014;348(g1687).
 56. World Health Organization. Everybody’s business. Strengthening health systems to improve health outcomes. WHO’s framework for action. Geneva; 2007.
 57. Chiu C, Scott NA, Kaiser JL, Ngoma T, Lori JR, Boyd CJ, et al. Household saving during pregnancy and facility delivery in Zambia: a cross-sectional study. *Heal Policy Plan*. 2019;34:102–9.
 58. World Health Organization. Maternity Waiting Homes: A review of experiences. Geneva; 1996.
 59. Asresie MB, Dagne GW. Effect of attending pregnant women’s conference on institutional delivery, Northwest Ethiopia: comparative cross-sectional study. *BMC Pregnancy Childbirth*. 2019;19(353).
 60. Dall’erba S. Exploratory Spatial Data Analysis. In: Kitchin R, Thrift N, editors. *Encyclopedia*

- of Human Geography. Amsterdam, Boston: Elsevier Ltd; 2009. p. 683–90.
61. O’Sullivan D, Unwin DJ. Geographic Information Analysis. 2nd ed. New Jersey: Wiley & Sons Inc; 2010.
 62. O’Sullivan D, Unwin DJ. Area Objects and Spatial Autocorrelation. 2nd Ed. Geographic Information Analysis. Hoboken, New Jersey: John Wiley & Sons Ltd; 2010. 187–214 p.
 63. World Health Organization. Closing The Gap in a Generation. Health equity through action on the social determinants of health. Geneva; 2008.
 64. Gangodagamage C, Zhou X, Lin H. Spatial autocorrelation. In: Shekhar S, Xiong H, editors. GIS Encyclopedia. 2nd ed. Geneva, Switzerland: Springer International; 2016. p. 32–7.
 65. ESRI. ArcMap Toolbox documentation [Internet]. [cited 2019 Sep 17]. Available from: <https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/index.html>
 66. Fotheringham AS, Brunsdon C, Charlton M. Quantitative Geography. London: SAGE Publications Inc; 2011.
 67. Castro MC De, Singer BH. Controlling the False Discovery Rate: A New Application to Account for Multiple and Dependent Tests in Local Statistics of Spatial Association. *Geogr Anal.* 2006;38:180–208.
 68. Kulldorff M. A spatial scan statistic. *Community Stat.* 1997;26(6):1481–96.
 69. Maciejewski R. Visual representations and analysis. In: Data representations, transformations and statistics for visual reasoning. Morgan & Claypool; 2011.
 70. Kulldorff M. SaTScan User Guide for version 9.6 [Internet]. 2018 [cited 2019 Jan 11]. Available from: <http://www.satscan.org>
 71. Kulldorff M. SaTScan. Software for the spatial, temporal and space-time scan statistics. Boston; 2005.
 72. Blanford JJ, Kumar S, Luo W, MacEachren AM. It’s a long, long walk: accessibility to hospitals, maternity and integrated health centers in Niger. *Int J Health Geogr.* 2012;11(24).
 73. Tanser F, Gijsbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa: An exploration using a geographical information system. *Soc Sci Med.* 2006;63:691–705.
 74. Anselin L. Spatial Regression. In: Fotheringham AS, Rogerson PA, editors. *The SAGE Handbook of Spatial Analysis*. London: SAGE Publications Ltd; 2009. p. 255–76.
 75. Fotheringham AS, Brunsdon C, Charlton M. Geographically weighted regression. Chichester: John Wiley & Sons Ltd; 2002.
 76. Sankey TT. Scale Effects. In: Shekhar S, Xiong H, editors. *Encyclopedia of GIS*. Boston: Springer; 2016.
 77. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes.* 2015;8(376).
 78. Mezmur M, Navaneetham K, Letamo G, Bariagaber H. Individual, household and contextual factors associated with skilled delivery care in Ethiopia: Evidence from Ethiopian demographic and health surveys. *PLoS One.* 2017;12(9).
 79. ICF International. Sampling and household listing manual. Demographic and Health Surveys methodology. Calverton, Maryland; 2012.
 80. Fotheringham AS, Yang W, Kang W. Multiscale Geographically Weighted Regression (MGWR). *Ann Am Assoc Geogr.* 2017;107(6):1247–65.

81. Dormann CF, Elith J, Bacher S, Buchmann C, Carl G, Carre G, et al. Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography (Cop)*. 2013;36:27–46.
82. Wheeler D, Tiefelsdorf M. Multicollinearity and correlation among local regression coefficients in geographically weighted regression. *J Geogr Syst*. 2005;7:161–87.
83. Fotheringham AS, Oshan TM. Geographically weighted regression and multicollinearity: dispelling the myth. *J Geogr Syst*. 2016;18:303–29.
84. Wheeler DC. Diagnostic tools and a remedial method for collinearity in geographically weighted regression. *Environ Plan Ann*. 2007;39:2464–82.
85. Da Silva RA, Fotheringham SA. The Multiple Testing Issue in Geographically Weighted Regression. *Geogr Anal*. 2016;48:233–47.
86. McCoy EC. Understanding the Intention-to-treat Principle in Randomized Controlled Trials. *West J Emerg Med*. 2017;18(6):1075–8.
87. Hooper R, Forbes A, Hemming K, Takeda A, Beresford L. Analysis of cluster randomised trials with an assessment of outcome at baseline. *BMJ*. 2018;360(k1121).
88. Coffman CJ, Edelman D, Woolson RF. To condition or not condition? Analysing ‘change’ in longitudinal randomised controlled trials. *BMJ Open*. 2016;6(e013096).
89. Fitzmaurice GM, Laird NM, Ware JH. Modeling the Mean: Analyzing Response Profiles. In: *Applied Longitudinal Analysis*. 2nd ed. Hoboken, New Jersey: John Wiley & Sons Ltd; 2011.
90. Kernan WN, Viscoli CM, Makuch RW, Brass LM, Horwitz RI. Stratified randomization for clinical trials. *J Clin Epidemiol*. 1999;52(1):19–26.
91. Kahan BC, Morris TP. Reporting and analysis of trials using stratified randomisation in leading medical journals: review and reanalysis. *BMJ*. 2012;345(e5840).
92. Stroup W. Generalized Linear Mixed Models. Modern concepts, methods and applications. Boca Raton: CRC Press, Taylor & Francis Group; 2013.
93. Kiernan K. Insights into Using the GLIMMIX Procedure to Model Categorical Outcomes with Random Effects. 2018. Report No.: SAS2179-2018.
94. Schabenberger O. Introducing the GLIMMIX procedure for Generalized Linear Mixed Models. Cary; 2018. (Statistics and Data Analysis). Report No.: SUGI 30: Paper 196-30.
95. Jones A, Arnold T. SAS/STAT 9.22 User Guide. Cary; 2010.
96. EuroQol. EQ-5D [Internet]. 2009 [cited 2020 Oct 19]. Available from: <https://euroqol.org/eq-5d-instruments/eq-5d-3l-about/>
97. Jimma Zone Health Office. MWH performance status in Jimma Zone Woredas. Jimma; 2016.
98. Kitchin R, Perkins C, Dodge M. Rethinking maps and identity: choropleths, clines and biopolitics. In: Dodge M, Kitchin R, Perkins C, editors. *Rethinking maps*. New York: Routledge; 2009.
99. Harrell FE. Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression and Survival Analysis. New York: Springer Science and Business Media; 2001.

Chapter 4: What factors influence whether or not rural Ethiopian women use maternity waiting homes?

4.1. Article preface

Before evaluating the effectiveness of upgraded MWHs in increasing the use of delivery care, it was important to understand what was driving the use (or non-use) of MWHs. Very few studies were available to answer this question and none included women randomly selected from the community. This work was, therefore, a logical starting point for my thesis. I used baseline household survey data from the trial to identify what factors, at the individual woman level but also other contextual spheres such as her household and her community, seemed to correlate with MWH use.

The objective of this article was to identify individual-, household- and community-level factors associated with MWH use in a rural, low-resource setting using baseline household survey data collected in three districts in Jimma Zone, Ethiopia.

4.1.1. Author contributions

I conceived of the research question based on my review of the literature. I designed the analysis with guidance from my supervisor, Dr. Manisha Kulkarni and thesis advisory committee (TAC) member, Dr. Monica Taljaard. I formulated the survey questions in the MWH modules of both the women's and husband's questionnaires used for data collection based on my literature review and field experience; Mr. Lakew Abebe, Dr. Sudhakar Morankar, Dr. Muluemebet Wordofa and Ms. Yisalemush Asefa provided input on the questions and response options. I cleaned the raw survey data and then conducted all the analyses based on feedback from Drs. Kulkarni and Taljaard. I drafted the manuscript and made revisions based on comments from other co-authors as well as colleagues (Dr. Zohra Lassi and Dr. Donald Cole) and TAC members (Dr. Gail Webber and Dr. Vivian Welch). All co-authors assisted in interpreting the results of the analysis.

4.1.2. Associated appendices

Details about how the asset-based wealth index was generated is included in Appendix 4.1. In Appendix 4.2, I present the results of the MWH use model using straight-line distances (calculated using GPS locations of households and health centres) instead of travel time estimates provided by women. While women's estimates also provide an indication of perceived distances and reflect the mode of transport they have access to, calculated distances offer an objective alternative to understanding the role of physical accessibility in MWH use. An opinion piece, that I co-authored with Dr. Kayli Wild (La Trobe University, Australia), on how MWHs fare during times of crises such as the

COVID pandemic or in post-conflict settings is included in Appendix 4.3 as further context to what influences MWH use.

4.1.3. Ethics approvals

Ethics approval for the overall study was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Ethics approval for my doctoral research was obtained from the University of Ottawa Health Sciences and Science REB (File No: H02-18-02).

4.1.4. Article citation

Kurji J, Gebretsadik LA, Wordofa MA, et al. Factors associated with maternity waiting home use among women in Jimma Zone, Ethiopia: a multilevel cross-sectional analysis *BMJ Open* 2019; 9:e028210. doi: 10.1136/bmjopen-2018-028210.

4.2. **Article content**

Article title: Factors associated with maternity waiting home use among women in Jimma Zone, Ethiopia: a, multi-level, cross-sectional analysis

Authors:

Jaameeta Kurji
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

Lakew Abebe Gebretsadik
Department of Health, Behaviour & Society, Jimma University, Jimma, Ethiopia

Muluemebet Abera Wordofa
Department of Population & Family Health, Jimma University, Jimma, Ethiopia

Sudhakar Morankar
Department of Health, Behaviour & Society, Jimma University, Jimma, Ethiopia

Yisalemush Asefa
Department of Health Economics, Management & Policy, Jimma University, Jimma, Ethiopia

Getachew Kiros
Department of Health, Behaviour & Society, Jimma University, Jimma, Ethiopia

Abebe Mamo
Department of Health, Behaviour & Society, Jimma University, Jimma, Ethiopia

Nicole Bergen
Faculty of Health Sciences, University of Ottawa, Ottawa, Canada

Shifera Asfaw
Department of Health, Behaviour & Society, Jimma University, Jimma, Ethiopia

Kunuz Haji Bedru
Jimma Zone Health Office, Jimma Zone, Oromia Region, Ethiopia

Gebeyehu Bulcha
Jimma Zone Health Office, Jimma Zone, Oromia Region, Ethiopia

Ronald Labonté
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

Monica Taljaard
Ottawa Hospital Research Institute, Ottawa, Canada

Manisha A. Kulkarni
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

4.2.1. Abstract

Objective: To identify individual-, household- and community-level factors associated with maternity waiting home (MWH) use in Ethiopia.

Design: Cross-sectional analysis of baseline household survey data from an on-going cluster-randomized controlled trial using multi-level analyses.

Setting: Twenty-four, rural primary care facility catchment areas in Jimma Zone, Ethiopia

Participants: 3,784 women who had a pregnancy outcome (livebirth, stillbirth, spontaneous/induced abortion) twelve months prior to September 2016.

Outcome measure: the primary outcome was self-reported MWH use for any pregnancy; hypothesized factors associated with MWH use included woman's education, woman's occupation, household wealth, involvement in health-related decision-making, companion support, travel time to health facility and community-levels of institutional births.

Results: Overall, 7% of women reported past MWH use. Housewives (Odds-ratio (OR): 1.74, 95% CI: 1.20, 2.52), women with companions for facility visits (OR: 2.15, 95% CI: 1.44, 3.23), wealthier households (4th vs. 1st quintile OR:3.20, 95% CI: 1.93, 5.33) and those with no health facility nearby or living > 30 minutes from a health facility (OR: 2.37, 95% CI: 1.80, 3.13) had significantly higher odds of MWH use. Education, decision-making autonomy and community-level institutional births were not significantly associated with MWH use.

Conclusions: Utilization inequities exist; women with less wealth and companion support experienced more difficulties in accessing MWHs. Short duration of stay and failure to consider MWH as part of birth preparedness planning suggests local referral and promotion practices need investigation to ensure that women who would benefit the most are linked to MWH services.

4.2.2. Strengths & limitations of this study

- A notable strength of the study was the simultaneous consideration of individual-level and contextual-level factors associated with actual MWH use using a relatively large, community-based dataset; several studies conducted on MWH use have focused on the influence of service quality.
- We used statistical analyses which explicitly accounted for the clustered nature of our data through generalized linear mixed models.
- The cross-sectional nature of the analysis limits our ability to make any conclusions about the causal relationship between hypothesized influential factors and MWH use.

4.2.3. Introduction

Maternal mortality has declined significantly in Ethiopia over the last two decades. It was estimated to be 720 deaths per 100,000 livebirths in 2005 (1) but dropped to 412 deaths per 100,000 livebirths by 2016.(2) Making motherhood safer is a priority for the Ethiopian government and various efforts, such as establishing the Health Extension Programme (HEP) (3), have been directed to reduce maternal mortality. Also among these has been the scale-up of maternity waiting homes (MWHs)(4), which were initially concentrated at the hospital level (5) but have more recently been implemented at lower-level health centres. MWHs are temporary residential spaces located within or close to health facilities offering skilled obstetric care. They provide an opportunity for pregnant women who experience geographical barriers to be near a health facility a few weeks before birth. MWHs have also been recommended for housing pregnant women who may be at risk of delivery complications so that they can be closely monitored by health workers.(6)

Utilization levels of MWHs globally have generally been reported to be lower than capacity with their conditions often regarded as unsatisfactory.(7,8) Formative work in Zambia revealed that perceptions about discomfort experienced at MWH because of overcrowding, lack of beds and water shortages can influence use;(9) in Malawi, satisfaction with MWHs was associated with decent toilets and showers, accommodation for companions, adequate sleeping areas and availability of private storage spaces among other amenities.(10) In Kenya, women were unhappy with health worker attitudes and felt that staff should check on them more often during their stay at the MWH.(11) Ethiopian users wished for better quality meals and in many cases had to rely on family for food supplies.(5)

While service quality plays an important role in MWH use, other factors may do so as well and need to be considered to optimize utilization. A cross-sectional, facility based survey in Tanzania found that women's socio-economic status and distance from health facility were associated with having stayed at an MWH prior to delivery.(12) In Ethiopia, intended MWH use was reported to be associated with history of obstetric complications and not perceiving barriers to MWH use.(13) A Zambian household survey reported marital status and distance being statistically associated with being an MWH user.(14) As part of the continuum of maternal healthcare services, it is also conceivable that factors shaping the usage of other services may also influence MWH use, as the service largely functions to link women to obstetric care. Women's education level, (15,16) household wealth, (15,17) decision-making dynamics, (15) social norms around service use, (18) and travel time to care facility (19) have been reported to influence use of antenatal, obstetric or postnatal care services in Ethiopia and in a number of countries in Sub-Saharan Africa.

Consideration of individual and contextual factors when examining women's access to health services is key. Service use, a proxy for access to care, is influenced by availability of quality services but also by women's ability to obtain these services.(20) Women's ability in turn is shaped by household and community level factors. (21) To have equitable, gender-responsive health systems that cater to the specific needs of women facing a multitude of structural barriers, requires a holistic understanding of the factors shaping use. (22)

The primary objective of this analysis, therefore, was to identify factors associated with maternity waiting home use at the individual, household and community levels among women in Jimma Zone, Ethiopia. A secondary objective was to describe community awareness of MWH services and user experiences in the area.

4.2.4. Methods

4.2.4.1. Study setting

Data used in this analysis were collected from three districts in Jimma Zone located in the southern part of Ethiopia. Gomma, Seka Chekorsa and Kersa districts are primarily rural and had populations ranging from 180,000 to 270,000 in 2016.(23) The districts were purposefully selected from the 21 comprising Jimma Zone as they had the largest available population sizes compared to other districts, had poorly functioning MWHs according to Jimma Zone Health Office (JZHO) data, and did not have ongoing maternal health interventions, such as other research or development projects or maternal health campaigns, to minimize potential co-interventions and to facilitate a more even distribution of interventions as requested by our JZHO partners.

Ethiopia's three-tiered healthcare system consists of a district hospital and primary health care units (PHCUs) - made up of a health centre and community-based health posts - at the bottom tier. Levels two and three include general and specialised hospitals, respectively.(3) In partnership with the District Health Offices, the JZHO oversees service delivery at the 26 health centres present in the study area.

All health centres have either temporary spaces or permanent, standalone structures designated to provide MWH services. According to the national guidelines, women who live far away from health centres, are inaccessible by ambulance, are 38 weeks or more pregnant and/or are at risk of experiencing obstetric complications during delivery are eligible for MWH referral.(4) MWHs are typically expected to consist of two rooms each accommodating six women and to have a suitable space equipped with utensils for women to prepare food, or offer meals to women who cannot afford to provide for themselves. MWHs should have access to clean water, latrines and a power source.(4) Exit surveys conducted nationally in 2016 revealed only 50% of rural MWHs had water available, 65% had an electricity supply and 73% had latrines, although most were shared with other patients.(24) As part of the country's strategy to reduce maternal mortality, the MWH policy was drafted in 2013 to standardize the service provision of this joint community-health system, fee-free initiative. MWH operations are mainly sustained through community cash or crop contributions while management is handled by health centre staff. Reliance on community contributions may result in some variation between the districts in the quality and availability of MWH services.

Health extension workers (HEWs), based in health posts, link communities to the health system by tracking pregnant women in their catchment areas and referring them for services. (25) Additionally, HEWs provide community-based primary health care as prescribed in the 16 modules of the HEP; HEWs offer education and counselling, conduct physical exams of pregnant women, make referrals to health facilities among other antenatal services at the health post. They also conduct postnatal home visits to check up on mothers and babies.(3,26)

4.2.4.2. Background about the trial and baseline survey

The data source for this analysis was a baseline survey conducted prior to intervention roll-out in an on-going cluster-randomized controlled trial aiming to evaluate the effectiveness of two safe motherhood interventions in improving institutional births: (i) functional MWHs and (ii) local leader education (ClinicalTrials.gov Identifier: NCT03299491). The MWH component focuses on improving amenities and services available at the MWHs to improve uptake. The education component targets village and religious leaders and uses culturally sensitive trainings to highlight the importance of safe

motherhood and delivering at health facilities; materials were developed to address the barriers to maternal care identified in the Three Delays framework. (27)

The survey targeted 3,840 women (24 clusters with 160 each); the sample size was determined by the primary outcome (institutional delivery) of the trial.(28) This sample size achieves 80% power to detect an absolute difference in the proportions of institutional delivery of 0.17 assuming a control arm proportion of 0.4 and using a two-sided alpha of 0.025 to account for two pairwise comparisons. Women living within catchment areas of trial PHCUs who had a pregnancy outcome (livebirth, stillbirth, miscarriage or abortion) up to one year prior to the survey were eligible. A two-stage sampling strategy was employed. First, 24 PHCUs were randomly selected for the trial. Then, 160 women per PHCU were randomly selected from community-based lists of pregnant women generated as part of health post records. HEWs and the Women's Development Army (community-based administration) periodically update these lists.

During household interviews conducted between October 2016 and January 2017, data were collected on sociodemographic characteristics, reproductive history, utilization of various maternal healthcare services including MWHs, decision-making and social support. Structured questionnaires were mostly developed by adapting questions from the Demographic and Health Surveys. Questionnaires were piloted in Mana district, located adjacent to the study districts, and refined based on participant and interviewer feedback on question and response acceptability as well as interview duration. Adaptations primarily involved providing response options suited to the study area. Questionnaires were programmed in Open Data Kit on tablet computers in English, Afaan Oromo and Amharic for data collection. Translations were verified by research team members fluent in these languages. Trained research assistants conducted face-to-face interviews with women in a quiet, private space at the women's homes; interviews took about one hour to complete. Husbands were also interviewed using a shorter version of the women's questionnaire that included information on travel times to health facilities. Data were available for 3,784 (98.5%) women recruited; due to lack of time, illness or the need for husband permission, 56 (1%) women refused to take part in the study.

4.2.4.3. *Variables of interest*

Definitions of variables used in this analysis are presented in Table 4.1. The primary outcome was self-reported MWH use for any pregnancy. Candidate explanatory variables, identified from the literature, and hypothesized to be associated with MWH use at the individual level were women's education and women's occupation; at the household level, household wealth, women's involvement in healthcare-related decision making, having a companion to accompany women for health facility visits during pregnancy, and travel time from home to nearest health centre were considered.

The household wealth variable was created using principal components analysis of items listed in Table 1; items were selected to minimize clustering and truncation which compromise reliability.(29) Briefly, socio-economic “scores” were generated for each household, which were then grouped into quintiles; the lowest quintile corresponded to the poorest households and the 5th quintile corresponding to the least poor households.(29)

To allow us to explore the potential effect of community birthing norms on MWH use, the percentage of women delivering at a health facility was calculated for each PHCU catchment area and the PHCU-level means compared between MWH users versus non-users; the use of similar proxy variables for social norms have been used to explore contextual effects on utilization of maternal healthcare services in studies conducted in Ethiopia (18) and Africa. (30)

Table 4.1. Definitions of variables used to explore factors associated with women’s use of MWHs in three districts in Jimma Zone, Ethiopia (2016-2017).

Variable	Definition
Outcome variable	
Maternity waiting home use	Binary variable indicating stay at an MWH reported by women for any previous pregnancy (yes or no).
Independent variables	
Education	Women’s responses on highest level of education completed (none, primary, secondary, tertiary) were collapsed into a binary variable (no formal schooling or some formal schooling).
Occupation	Women’s responses on their primary occupation were collapsed into a binary variable to reflect the main occupations listed (housewife or farmer/trader/other). Other occupations included government employee, student, domestic worker, private organization employee
Household wealth	An asset-based wealth index created using information on asset ownership (radio, television, mobile phone, motorbike, car/truck), number of animals owned (cows, sheep, poultry), electricity supply to home, health insurance, drinking water source, type of toilet and type materials used for construction of floors in the home.
Healthcare decision-making	Women were asked who usually makes decisions about (i) their own health and (ii) their children’s health. Women indicated whether they made decisions on their own, jointly with someone else or were not involved. Responses for both questions were collapsed into 3 categories: never involved, sometimes involved or always involved. “Never involved” included women who described someone other than themselves being involved in healthcare decision-making for both themselves and their children. “Sometimes involved” included women who described that they were either involved in healthcare decisions about their own health or decisions about their children’s health. “Always involved” included women who described being involved in both healthcare decisions about their own health and that of their children.

Variable	Definition
Companion support for facility visits ¹	As part of an assessment of social support available to women during pregnancy, women were asked if they had someone to accompany them to health facility visits (yes or no). This dimension of support has been termed companion support.
Travel time to obstetric care facility	Women's estimates of the time required to reach the nearest health facility able to provide obstetric care were classified into 2 categories: (i) None nearby (i.e. > 30 minutes) (ii) ≤ 30 minutes away. Women who listed a health post as their nearest health facility were classified under "None" as health posts do not routinely provide delivery services. For the 5% of women who were unable to estimate travel, available husband responses were used to minimize missing data.
Community birthing norms	Percentage of women in a PHCU cluster that reported having ever given birth at a health facility.
Covariates and design variables	
District	District of residence (Gomma, Seka Chekorsa or Kersa) reported by women
Primary Health Care Unit (PHCU)	Health system administrative level comprising a health centre and satellite health posts that functioned as cluster-level sampling unit in the trial

¹ Several dimensions of social support including financial or in-kind assistance, emotional support and practical support were assessed in the survey. Companion support was the dimension most relevant for maternity waiting home use.

4.2.4.4. Data analysis

Characteristics of MWH users and non-users were described using frequencies and proportions or means and standard deviations. Chi square tests for categorical variables, and t-tests for continuous variables adjusted for clustering were performed using methods of Donner & Klar.⁽³¹⁾ Frequencies and proportions of community awareness of MWHs, reasons for use among users and services available to users were also reported.

To identify variables associated with MWH use, multivariable generalized linear mixed effects regression was used. All candidate explanatory variables (education, occupation, household wealth, decision-making involvement, companion support, travel time and community birthing norms) were entered into the model. District of residence reported by the woman was included as a covariate to adjust for any district-level differences. A logit link function with a binomial distribution was used. To account for clustering, a random intercept was added for the PHCU. P-values less than 0.05 were considered to be statistically significant. Analysis was conducted in STATA v13.

4.2.4.5. Patient and public involvement

Patients/public were not involved in the design or implementation of this research. Results will be disseminated to policy-makers and local-level service implementers.

4.2.5. Results

4.2.5.1. *Characteristics of MWH users and non-users*

Overall, 256 (7%) of women had ever used MWH services. Women's mean age was 28 years (standard deviation: 6 years) and the majority (78%) had more than one child. There was a statistically significant difference in the proportions of women who reported being able to reach a health centre or hospital providing obstetric services within 30 minutes among users (49%) versus non-users (72%) (Table 4.2).

Although not statistically significant, a larger proportion of MWH users reported both primary (45% vs. 39% among non-users) and secondary or higher education levels (7% vs. 5% among non-users) and a slightly larger proportion tended to be housewives (86% vs. 77%). A greater fraction of the users than non-users came from wealthier households (91% vs. 79%) and reported having companion support for facility visits (88% vs. 77%) (Table 4.2). The proportion of women who described themselves as always being involved in healthcare-related decision-making was lower among MWH users (6%) than non-users (9%) (Table 4.2).

4.2.5.1. *Community exposure to MWHs and user experiences*

Overall, 2,679 (71%) women interviewed had heard about MWH services in their community but a smaller proportion knew of someone who had used one (36%) or had actually visited someone at an MWH (28%). Most women could describe at least one benefit of MWH use and these typically included easy access to skilled birth attendants (57%) and an opportunity to rest (43%). Only 16% of women recognized not having to organize emergency transport during labour as a benefit of MWH stay. Very few women who did report planning for their delivery listed getting an MWH referral ($n=34$, 1.3%) as a component of birth preparedness planning (results not shown in tables).

HEWs were important mediators of access to MWHs as almost 75% of users had obtained a referral from HEWs (Table 4.3). About 15% of users stayed at MWHs because they anticipated delivery complications and wanted to be close to health workers (Table 4.3). Only 12% of MWH users cited large distances between home and health centre as the reason for stay (Table 4.3).

Close to 60% of users were admitted just 24 hours prior to delivery; 25% of users reported staying at the MWH less than one week (1-7 days) prior to delivery while 16% were accommodated at the MWH for more than one week before giving birth (results not shown in tables). Most users were provided with some simple bedding and about 72% were given some food during their stay. However, clean water, lighting, bathing facilities and coffee ceremony (an important cultural routine in household

Table 4.2. Individual-, household and community level characteristics of MWH users compared to non-users in three districts in Jimma Zone, Ethiopia (2016-2017).

	MWH users (n=256)		MWH non-users (n=3,528)		Overall		p value
	Frequency (%)		Frequency (%)				
INDIVIDUAL LEVEL							
Age (years)							
< 20	18	(7.0 %)	230	(6.5 %)	248	(6.6 %)	0.687
20-30	177	(69.1 %)	2,180	(61.8 %)	2,357	(62.3 %)	
> 30	59	(23.1 %)	1,008	(28.6 %)	1,067	(28.2 %)	
Missing	2	(<1%)	110	(3.1 %)	112	(2.9 %)	
Education level							
None	123	(48.1 %)	1,978	(56.0 %)	2,101	(55.5 %)	0.577
Primary school	116	(45.3 %)	1,368	(38.8 %)	1,484	(39.2 %)	
≥ Secondary school	17	(6.6 %)	182	(5.2 %)	199	(5.3 %)	
Occupation							
Housewife	219	(85.6 %)	2,715	(77.0 %)	2,934	(77.5 %)	0.186
Farmer/trader/other	37	(14.4 %)	813	(23.0 %)	850	(22.5 %)	
Parity							
1 child	74	(28.9 %)	753	(21.3 %)	827	(21.9 %)	0.240
> 1 child	182	(71.1 %)	2,775	(78.7 %)	2,957	(78.1 %)	
HOUSEHOLD LEVEL							
Household wealth							
Poorest quintile	23	(9.0 %)	734	(20.8 %)	757	(20.0 %)	0.195
2 nd quintile	40	(15.6 %)	718	(20.4 %)	758	(20.0 %)	
3 rd quintile	52	(20.3 %)	703	(19.9%)	755	(19.9 %)	
4 th quintile	71	(27.7 %)	686	(19.5 %)	757	(20.0 %)	
Least poor quintile	70	(27.4 %)	686	(19.5%)	756	(20.0 %)	
Missing	0	-	1	(<1%)	1	(<1%)	
Healthcare decision involvement							
Never	57	(22.3 %)	768	(21.8 %)	825	(21.8 %)	0.703
Sometimes	185	(72.2 %)	2,435	(69.0 %)	2,620	(69.2 %)	
Always	14	(5.5 %)	324	(9.2 %)	338	(8.9 %)	
Missing	0	-	1	(<1%)	1	(<1%)	
Social support during pregnancy							
Practical help	226	(88.3 %)	3,202	(90.8 %)	3,428	(90.6 %)	0.586
Facility visit companion	225	(87.9 %)	2,723	(77.2 %)	2,948	(77.9 %)	0.097
Travel time to obstetric care facility							
≤ 30 min away	126	(49.2 %)	2,541	(72.0 %)	2,667	(70.5 %)	0.001
> 30 min (none nearby)	130	(50.8 %)	987	(28.0 %)	1,117	(29.5 %)	
COMMUNITY LEVEL	[mean % (SD)] ¹		[mean % (SD)] ²		[mean % (SD)]		
Community birthing norms	34.0	(12.0)	31.7	(11.2)	31.8	(11.2)	0.809

1 The PHCU-level percentage of women who reported ever giving birth at a health facility averaged across all PHCUs where MWH users live

2 The PHCU-level percentage of women who reported ever giving birth at a health facility averaged across all PHCUs where non users live

p-values <0.05 considered statistically significant

Table 4.3. Reasons for MWH stay, and services received among women users in three districts in Jimma Zone, Ethiopia 2016-2017 (n=256)

	Frequency	% Users ¹
Reasons for use		
HEW referral	191	74.6
Complications expected	37	14.5
Prior use of MWH	34	13.3
Live far from health facility	31	12.1
To ensure facility delivery	17	6.6
Needed rest	14	5.5
Other reasons	18	7.0
Services available during stay		
Bedding	253	98.8
Meals	184	71.9
Coffee	62	24.2
Latrines	203	79.3
Bathing facilities	82	32.0
Clean water	141	55.1
Electricity/lighting	114	44.5
Midwife checks	195	76.2

¹ Multiple responses possible, therefore, percentages do not sum to 100

that creates a home-like environment at MWHs) services were not widely available (Table 4.3). Just over a quarter of the women said family visits were permitted during their stay (results not shown in tables).

4.2.5.2. Multivariable regression analysis of factors associated with maternity waiting home use

One individual-level factor and three household-level factors resulted in statistically significant higher odds of ever having used an MWH. At the individual level, women's occupation was associated with MWH use. Housewives had higher odds of MWH use than women who had an occupation outside the home (OR:1.74, 95% CI: 1.20 to 2.52) (Table 4.4). At the household level, companion support, travel time to health facilities and household wealth were associated with MWH use.

Women who described having companions to accompany them for health facility visits when they were pregnant or for delivery had twice the odds of having used an MWH than women who did not have this form of social support (OR: 2.15, 95% CI: 1.44 to 3.23) (Table 4.4). Women who described living more than 30 minutes from a health centre or hospital offering obstetric care or reporting no such facility nearby had a higher odds of MWH use than those residing within 30 minutes (OR: 2.37, 95% CI: 1.80 to 3.13) (Table 4.4). Households with more wealth exhibited statistically significantly higher odds of MWH use compared to the poorest quintile.

4.2.1. Discussion

In this study we found that the majority of women in our study were aware of the existence of MWHs but a very small proportion reported ever actually having used the service. A cross-sectional study conducted in 2014 in Eastern Gurage Zone, Ethiopia reported just 7% of women interviewed being aware of MWH services compared to 71% in our study.(13) The formalization of the national MWH guidelines in 2015 (4) and clarification of roles of various levels of government as well as HEWs in promoting MWH use may have influenced community awareness about the MWHs.

Table 4.4. Results from multivariable random effects logistic regression analysis of MWH use among women in Jimma Zone, Ethiopia (n=3,782)

	Odds Ratio (95% CI)	p-values
Individual Level		
Education		
No formal schooling	1	
Some formal schooling	1.08 (0.82, 1.43)	0.578
Occupation		
Farmer/trader/other	1	
Housewife	1.74 (1.20, 2.52)	0.003
Household Level		
Household wealth		
Poorest	1	
2 nd quintile	1.85 (1.08, 3.17)	0.026
3 rd quintile	2.39 (1.42, 4.03)	0.001
4 th quintile	3.20 (1.93, 5.33)	<0.001
Least poor	2.39 (1.40, 4.09)	0.001
Healthcare decision making		
Never involved	1	
Sometimes involved	0.86 (0.62, 1.20)	0.378
Always involved	0.59 (0.32, 1.09)	0.094
Companion for facility visits		
Absent	1	
Present	2.15 (1.44, 3.23)	<0.001
Travel time to obstetric care facility		
≤ 30 minutes away	1	
> 30 minutes (none nearby)	2.37 (1.80, 3.13)	<0.001
Community Level		
Community birthing norms	1.00 (0.95, 1.06)	0.953
Covariates		
District of residence		
Gomma	1	
Kersa	0.88 (0.20, 3.98)	0.870
Seka Chekorsa	0.64 (0.21, 1.94)	0.429

p-values <0.05 considered statistically significant

Most users accessed MWHs through referrals from health extension workers or health workers during ANC and generally stayed at MWHs for less than 24 hours before delivering their baby. The relatively short duration of stay suggests that many users are women who may be presenting with false or very early labour and are accommodated temporarily at the MWH; this may be due to the fact that they are not being referred to MWHs one to two weeks prior to delivery as recommended.(4) Alternatively, while institutional births are valued by the population, MWHs may not necessarily be viewed as a service that facilitates access to obstetric services by offering women the opportunity to be closer skilled birth attendants prior to delivery. Indeed, while most women were aware of MWH services, very few women who reported practicing birth preparedness considered MWHs as part of their plans to ensure access to obstetric care. This may partially explain why community norms around facility deliveries were not significantly associated with MWH use. Therefore, referral practices around, and promotion of, MWH use employed by HEWs and health workers in the area require investigation to ensure that the women who would benefit the most from this service are being reached. Qualitative reports of HEW perceptions influencing promotion of MWHs to the community has been reported in this area.(32)

Being a housewife, coming from relatively wealthier households, having companions to accompany women to health facilities and living more than 30 minutes from a health facility was associated with increased odds of MWH use. Despite MWH services being free, there may be financial and social costs associated with lodging there. Women from wealthier households are probably more likely to be able to afford to pay for transport, purchase food, and accommodate accompanying relatives. Both direct and indirect costs have been described as barriers to MWH use in Ethiopia (5,33) and other settings.(34) Some studies have reported an inverse relationship between MWH use and household wealth in bivariable analysis (35,36) and after adjusting for confounders.(12) Various measures and cut-offs were also used to determine relative wealth, including asking women to rate their household wealth in relation to their neighbours, (35) which may partially account for the difference in findings. Our results suggest there may be a threshold wealth level after which households with more means may explore alternatives to MWHs such as paying for transport when women go into labour or going directly to a higher-level facility; this requires additional investigation. Extended absences from the home also result in losses of income that poor families can ill afford and can affect both intended and actual use. (13,37)

Although most women in our study identified themselves as housewives without formal occupation commitments, close to 65% of these women said that they had worked in the past 12 months. Anecdotal evidence from the area suggests that in many cases women contribute to family farms and informal trade. However, compared to women with other occupations, housewives were more likely to

report having used MWH services. This suggests that women without formal work commitments may have more flexibility to stay at MWHs if they have the means and social support to facilitate this.

Social support has been described as an important facilitator of MWH use across several low- and middle-income countries. (8) Women are frequently reluctant to stay at MWHs because it means leaving children unattended at home in the absence of help with childcare.(13,38,39) The presence of family to support and provide reassurance to women during birth is important and may even affect health and well-being of mother and baby.(40) In fact, being surrounded by family and the comfort of home has been reported to be why some women prefer home births over facility deliveries.(19,41,42) This is important to consider as MWHs function as one of the entry-points to facility-based obstetric care and likely share similar barriers to their use. Moreover, women often need to have someone help them prepare meals, fetch firewood and clean water while staying at MWHs. (5,33) Although 71% of MWH users in our surveyed reported receiving a meal during their stay, this typically consists of a bowl of gruel (porridge) usually prepared for women post-delivery. Moreover, reliance on community contributions to sustain the MWHs regularly results in food shortages according to anecdotal evidence generated during pre-intervention assessments. Therefore, women who have companions to accompany them at MWHs may not only have someone to facilitate their stay, but may also benefit from emotional support prior to and during birth, similar to the care that women receive at home, making MWH stay a more attractive option. Indeed, qualitative research from our setting (32) and other areas in Ethiopia (43) highlight the pivotal role of husbands and family support in enabling women's use of MWHs. Companions may also assist women receive the attention they need, but which they often do not get from health workers who have repeatedly been criticized for their neglect of MWH users. (11,44,45)

One of the functions of MWHs is to provide women who live at prohibitively large distances from health facilities the opportunity to access obstetric services by accommodating them prior to delivery.(6) It is, therefore, not surprising to find that women who report living within 30 minutes of a health facility are less inclined to use MWH services. In fact large distances between homes and health facilities are often part of MWH admission criteria.(4,11,35) Studies in Africa have reported distance from health facility affecting women's decisions to use MWH services (44) as well as being associated with use. (12)

One of the strengths of this study was the use of models that accounted for clustering in the data, which if ignored underestimates variance while overestimating significance.(46) Additionally, random selection of almost 4000 women from a representative community list should minimize the likelihood of selection bias. However, the cross-sectional nature of the analysis does not support causal inference limiting this to an exploratory exercise to identify factors that may influence MWH use. Also, the primary outcome relied on women's self-reported MWH use which may be subject to recall bias.

However, this risk is likely low because staying at an MWH prior to delivery is expected to be a notable experience. Women's self-reported travel times estimates may not accurately reflect physical accessibility of MWHs; calculation of distances is recommended for future studies to assess the distance threshold for MWH use. Our results may have generalizability limited to districts with similar profiles to ours given the purposive nature of district selection.

In conclusion, investigating what context-relevant factors influence the use of MWHs will help to better tailor care to suit women's needs. Our findings have important implications for achieving equity in access to maternal healthcare as poorer women, with little social support in the form of companions accompanying them for health facility visits, are likely to be among the more vulnerable groups. Further research into referral and promotion practices may also be warranted as results indicate sub-optimal duration of stay at MWHs. When designing MWH programs, it will be important to consider mobilizing community support to overcome financial constraints and boost social networks.

4.2.2. Acknowledgements

We would like to acknowledge the communities, survey staff and partners from the research areas who made this research possible. We thank Dr. Gail Webber, Dr. Vivian Welch, Dr. Donald Cole and Dr. Zohra Lassi for their comments on the manuscript.

4.2.3. Contributors

JK and MK conceived and designed this study; LAG, MAW, SM, KHB, GB, RL and MK designed the trial in which this study is nested. LAG, YA, GK, SM, AB, SA, and GB led data collection. JK, MK and MT conducted data analysis and interpretation. JK wrote up the manuscript. JK, MK, MT, LAG, MAW, SM, KHB, GB, RL, YA, GK, AB, SA, NB contributed to data interpretation, critically reviewed the manuscript and provided final approval.

4.2.4. Competing Interests

None declared

4.2.5. Funding

This work was carried out with the aid of a grant from the Innovating for Maternal and Child Health in Africa initiative- a partnership of Global Affairs Canada (GAC), the Canadian Institutes of Health Research (CIHR) and Canada's International Development Research Centre (IDRC).

4.2.6. Patient Consent & Ethical Approval

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Verbal informed consent for data collection was obtained from eligible women willing to participate in interviews. Trained research assistants read out the contents of the consent forms outlining the trial objectives, institutions and investigators involved and describing what was expected of women as well as associated risks and benefits. This was done in a local language of women's choice (Amharic or Afaan Oromo). Women were also explained their rights as participants and their questions answered prior to enrolment.

4.2.7. Data Sharing

Data used for this analysis will be provided by the authors upon reasonable request.

4.2.8. Article References

1. World Health Organization. World Health Statistics. 2010.
2. Central Statistical Agency, DHS Program ICF. Ethiopia Demographic and Health Survey 2016: Key Indicators Report. Addis Ababa and Rockville, Maryland; 2016.
3. Ethiopian Federal Ministry of Health. Health Sector Development Program IV: 2010/11 - 2014/15. 2010.
4. Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa; 2015.
5. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
6. World Health Organization. Maternity Waiting Homes: A review of experiences. Geneva; 1996.
7. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
8. Penn-Kekana L, Pereira S, Hussein J, Bontogon H, Chersich M, Munjanja S, et al. Understanding the implementation of maternity waiting homes in low- and middle-income countries: A qualitative thematic synthesis. *BMC Pregnancy Childbirth*. 2017;17(269).
9. Scott NA, Vian T, Kaiser JL, Ngoma T, Mataka K, Henry EG, et al. Listening to the community: Using formative research to strengthen maternity waiting homes in Zambia. *PLoS One*. 2018;13(3).
10. McIntosh N, Gruits P, Oppel E, Shao A. Built spaces and features associated with user satisfaction in maternity waiting homes in Malawi. *Midwifery*. 2018;62:96–103.

11. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynaecol Obstet.* 2010;108:152–3.
12. Fogliati P, Straneo M, Mangi S, Azzimonti G, Kisika F, Putoto G. A new use for an old tool: Maternity waiting homes to improve equity in rural childbirth care. Results from a cross-sectional hospital and community survey in Tanzania. *Health Policy Plan.* 2017;32:1354–60.
13. Vermeiden T, Braat F, Medhin G, Gaym A, van den Akker T, Stekelenburg J. Factors associated with intended use of a maternity waiting home in Southern Ethiopia: A community-based cross-sectional study. *BMC Pregnancy Childbirth.* 2018;18(38).
14. Lori JR, Boyd CJ, Munro-Kramer ML, Veliz PT, Henry EG, Kaiser J, et al. Characteristics of maternity waiting homes and the women who use them: Findings from a baseline cross-sectional household survey among SMGL-supported districts in Zambia. *PLoS One.* 2018;13(12).
15. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. *BMC Pregnancy Childbirth.* 2014;14(161).
16. Mohan D, Gupta S, LeFevre A, Bazant E, Killewo J, Baqui AH. Determinants of postnatal care use at health facilities in rural Tanzania: multilevel analysis of a household survey. *BMC Pregnancy Childbirthregnancy childbirth.* 2015;15(282).
17. Say L, Raine R. A systematic review of inequalities in the use of maternal health care in developing countries: examining the scale of the problem and the importance of context. *Bull World Heal Organ.* 2007;85:812–9.
18. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes.* 2015;8(376).
19. Hailu D, Berhe H. Determinants of institutional childbirth service utilisation among women of childbearing age in urban and rural areas of Tsegedie district, Ethiopia. *Midwifery.* 2014;30:1109–17.
20. Gulliford M, Figueroa-Munoz J, Morgan M, Hughes D, Gibson B, Beech R, et al. What does “access to health care” mean? *J Health Serv Res Policy.* 2002;7(3):186–8.
21. Braveman P, Gottlieb L. The Social Determinants of Health: It’s Time to Consider the Causes of the Causes. *Public Health Rep.* 2014;129(Suppl 2):19–31.
22. Temmerman M, Khosla R, Laski Z, Say L. Women’s health priorities and interventions. *BMJ.* 2015;351(h4147).
23. Oromiya Bureau of Finance and Economic Development. Oromiya Housing & Population Census. 2015.
24. Ethiopian Public Health Institute, Federal Ministry of Health Ethiopia, Columbia University. Ethiopian Emergency Obstetric and Newborn Care (EmONC) Assessment 2016. 2017.
25. Maternal Health Task Force. Health Extension Workers in Ethiopia. Delivering community-

- based antenatal and postnatal care. 2014.
26. Caglia J, Kearns A, Langer A. Health Extension Workers in Ethiopia. Delivering community-based antenatal and postnatal care. 2014.
 27. Thaddeus S, Maine D. Too To Walk: Maternal Mortality in Context. *Soc Sci Med*. 1994;38(8):1091–110.
 28. ClinicalTrials.gov. An Implementation Study of Interventions to Promote Safe Motherhood in Jimma Zone Ethiopia. National Library of Medicine (US). Bethesda;
 29. Vyas S, Kumaranayake L. Constructing socio-economic status indices: How to use principal components analysis. *Health Policy Plan*. 2006;21(6):459–68.
 30. Stephenson R, Baschieri A, Clements S, Hennink M, Madise N. Contextual influences on the use of health facilities for childbirth in Africa. *Am J Public Health*. 2006;96:84–93.
 31. Donner A, Klar N. Design and Analysis of Cluster Randomization Trials in Health Research. New York: Wiley; 2000.
 32. Bergen N, Abebe L, Asfaw S, Kiros G, Kulkarni MA. Maternity waiting areas – serving all women? Barriers and enablers of an equity-oriented maternal health intervention in Jimma Zone, Ethiopia. *Glob Public Health*. 2019;14(10):1509–23.
 33. Kelly J, Kohls E, Poovan P, Schiffer R, Redito A, Winter H, et al. The role of a maternity waiting area (MWA) in reducing maternal mortality and stillbirths in high-risk women in rural Ethiopia. *BJOG*. 2010;117(11):1377–83.
 34. Ruiz MJ, van Dijk MG, Berdichevsky K, Munguía A, Burks C, García SG. Barriers to the use of maternity waiting homes in indigenous regions of Guatemala: A study of users' and community members' perceptions. *Cult Heal Sex*. 2013;15(2):205–18.
 35. Braat F, Vermeiden T, Getnet G, Schiffer R, van den Akker T, Stekelenburg J. Comparison of pregnancy outcomes between maternity waiting home users and non-users at hospitals with and without a maternity waiting home: retrospective cohort study. *Int Health*. 2018;10:47–53.
 36. Singh K, Speizer I, Kim ET, Lemani C, Phoya A. Reaching vulnerable women through maternity waiting homes in Malawi. *Int J Gynaecol Obstet*. 2017;136:91–7.
 37. Wilson JB, Collison AHK, Richardson D, Kwofie G, Senah KA, Tinkorang EK. The maternity waiting home concept: The Nsawam, Ghana experience. *Int J Gynecol Obstet*. 1997;59(Suppl.2):S165–72.
 38. Sialubanje C, Massar K, Kirch EM, Van Der Pijl MSGG, Hamer DH, Ruiter RACC. Husbands' experiences and perceptions regarding the use of maternity waiting homes in rural Zambia. *Int J Gynecol Obstet*. 2016;133:108–11.
 39. Tiruneh GT, Taye BW, Karim AM, Betemariam WA, Zemichael NF, Wereta TG, et al. Maternity waiting homes in Rural Health Centers of Ethiopia: The situation, women's experiences and challenges. *J Heal Dev*. 2016;30(1):19–28.
 40. Bohren MA, Hofmeyr GJ, Sakala C, Fukuzawa RK, Cuthbert A. Continuous support for women

- during childbirth (Review). *Cochrane Database Syst Rev*. 2017;(7).
41. Sisay MM, Yirgu R, Gobezeayehu AG, Sibley LM. A qualitative study of attitudes and values surrounding stillbirth and neonatal mortality among grandmothers, mothers, and unmarried girls in rural Amhara and Oromiya regions, Ethiopia: Unheard souls in the backyard. *J Midwifery Women's Heal*. 2014;59:S110–7.
 42. Jackson R. “Waiting-to-see” if the baby will come: Findings from a qualitative study in Kafa Zone, Ethiopia. *Ethiop J Heal Dev*. 2013;27(2):118–23.
 43. Vermeiden T, Schiffer R, Langhorst J, Klappe N, Asera W, Getnet G, et al. Facilitators for maternity waiting home utilisation at Attat Hospital: a mixed-methods study based on 45 years of experience. *Trop Med Int Heal*. 2018;23(12):1332–41.
 44. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: Women's beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;12(61).
 45. Sundu S, Mwale OG, Chirwa E. Antenatal Mothers ' Experience of Staying in a Maternity Waiting Home at Malamulo Mission Hospital in Thyolo District Malawi : A Qualitative , Exploratory Study. *Women's Heal Gynecol Heal Gynecol*. 2017;3(1).
 46. Brown AW, Li P, Brown MMB, Kaiser KA, Keith SW, Oackes MJ, et al. Best (but oft-forgotten) practices: designing, analyzing, and reporting cluster randomized controlled trials. *Am J Clin Nutr*. 2015;102:241–8.

Chapter 5: How does maternal healthcare service use vary within rural Ethiopia?

5.1. Article preface

As a first step to investigating how factors that influence maternal healthcare service use may change depending on local context, I used spatial methods to visualize and explore the patterns of service use that exist at several sub-national levels. I used the baseline household survey dataset to identify localities where unusually high or low levels of service use clusters. I also examined correlations between two commonly reported factors, education and wealth, and service use as these have important implications for inequities in access to services.

5.1.1. Author contributions

I formulated the research objectives associated with this article, conducted the analyses and wrote the first draft of the manuscript with guidance from Dr. Manisha Kulkarni. Dr. Benoit Talbot assisted with identifying appropriate tools in ArcMap to create map outputs and made design suggestions on choropleths to illustrate correlations between service use and indicators in the most visually effective style. All authors reviewed the initial draft of the manuscript, provided their feedback on interpretation of the findings and general flow and presentation of the manuscript. All authors also provided comments on the responses to reviewer comments as part of the peer review process.

5.1.2. Associated appendices

None

5.1.3. Ethics approvals

Ethics approval for the overall study was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Ethics approval for my doctoral research was obtained from the University of Ottawa Health Sciences and Science REB (File No: H02-18-02).

5.1.4. Article citation

Kurji, J., Talbot, B., Bulcha, G. et al. Uncovering spatial variation in maternal healthcare service use at subnational level in Jimma Zone, Ethiopia. *BMC Health Serv Res* 20, 703 (2020).

<https://doi.org/10.1186/s12913-020-05572-0>

5.2. Article content

Article title: Spatial variation in sub-national utilization of maternal health care services in Jimma Zone, Ethiopia

Authors:

Jaameeta Kurji
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

Benoit Talbot
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

Gebeyehu Bulcha
Jimma Zone Health Office, Jimma Town, Jimma Zone, Ethiopia

Kunuz Haji Bedru
Jimma Zone Health Office, Jimma Town, Jimma Zone, Ethiopia

Sudhakar Morankar
Department of Health, Behaviour and Society, Jimma University, Jimma, Ethiopia

Lakew Abebe Gebretsadik
Department of Health, Behaviour and Society, Jimma University, Jimma, Ethiopia

Muluemebet Abera Wordofa
Department of Population and Family Health, Jimma University, Jimma, Ethiopia

Vivian Welch
Centre for Global Health, Bruyere Research Institute, Ottawa, Canada

Ronald Labonté
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

Manisha A. Kulkarni
School of Epidemiology and Public Health, University of Ottawa, Ottawa, Canada

5.2.1. Abstract

Background: Analysis of disaggregated national data suggest uneven access to essential maternal healthcare services within countries. This is of concern as it hinders equitable progress in health outcomes. Mounting an effective response requires identification of subnational areas that may be lagging behind. This paper aims to explore spatial variation in maternal healthcare service use at health centre catchment, village and household levels. Spatial correlations of service use with household wealth and women's education levels were also assessed.

Methods: Using survey data from 3,758 households enrolled in a cluster randomized trial geographical variation in the use of maternity waiting homes (MWH), antenatal care (ANC), delivery care and

postnatal care (PNC) was investigated in three districts in Jimma Zone. Correlations of service use with education and wealth levels were also explored among 24 health centre catchment areas using choropleth maps. Global spatial autocorrelation was assessed using Moran's I. Cluster analyses were performed at village and household levels using Getis Ord Gi* and Kulldorf spatial scan statistics to identify cluster locations.

Results: Significant global spatial autocorrelation was present in ANC use (Moran's $I=0.15$, p value= 0.025), delivery care (Moran's $I=0.17$, p value= 0.01) and PNC use (Moran's $I=0.31$, p value <0.01), but not MWH use (Moran's $I=-0.005$, p value = 0.94) suggesting clustering of villages with similarly high (hot spots) and/low (cold spots) service use. Hot spots were detected in health centre catchments in Gomma district while Kersa district had cold spots. High poverty or low education catchments generally had low levels of service use, but there were exceptions. At village level, hot and cold spots were detected for ANC, delivery care and PNC use. Household-level analyses revealed a primary cluster of elevated MWH-use not detected previously. Further investigation of spatial heterogeneity is warranted.

Conclusions: Sub-national variation in maternal healthcare services exists in Jimma Zone. There was relatively higher poverty and lower education in areas where service use cold spots were identified. Re-directing resources to vulnerable sub-groups and locations lagging behind will be necessary to ensure equitable progress in maternal health.

5.2.2. Introduction

Improvements in access to services across the continuum of maternal healthcare have been reported throughout the world but progress has been unequal.(1) In addition to differential successes between countries, uneven access to essential maternal healthcare services within countries have also been revealed (2) using disaggregated national data. In Ethiopia, nationally representative Demographic and Health Survey (DHS) data show markedly different service coverage levels associated with reductions in maternal mortality; in 2016, the proportion of births at health facilities ranged from close to 60% in Tigray and Dire Dawa regions to under 20% in Somali and Affar regions. (3)

Of major concern is the fact that women who are the most vulnerable and likely in need of healthcare services may be least likely to access them. Inequity in health arises as a result of “unfair and avoidable” differences.(4) The concept is linked to that of the social determinants of health which recognizes that the conditions in which individuals live shape their ability to access resources and can result in unfair disadvantages thus perpetuating inequalities in health outcomes.(5) Improving equitable outcomes in multiple domains affecting health and human development underlies the 2015 Sustainable

Development Goals, including an explicit goal to “reduce inequality between and within countries” (Goal 10), highlighting the value placed on this principle by most of the world’s governments.(6)

Inequalities in maternal healthcare service use have been reported across countries in sub-Saharan Africa.(7–9) Education and household wealth are important factors affecting access to services. Several cross-sectional studies in Ethiopia have reported that women with higher levels of education are more likely to have used antenatal care (ANC) (10,11) and have given birth at a health facility.(12–14) Similar associations have been reported wherein increases in household wealth have corresponded with increased odds of maternal healthcare service use. (11,15)

Decentralization of health service provision and management means that local level policy makers require evidence about service utilization at that level. Spatial analyses present a powerful medium for visually demonstrating service utilization patterns at various geographic levels. Superimposition of data layers can help end users ascertain which areas require attention and identify marginalized populations that require targeted support.

In this paper, we explore spatial variation in the utilization of antenatal, delivery and postnatal care (PNC) services and use of maternity waiting homes (MWH) at health centre catchment and village levels, and to assess spatial correlations with household wealth and women’s education levels in three rural districts in Ethiopia.

5.2.3. Methods

5.2.3.1. *Study setting*

Ethiopia is composed of nine regional states and two city administrations; these are sub-divided into *woredas* (districts) which comprise several *kebeles* (villages). This analysis focuses on three rural *woredas* (Gomma, Seka Chekorsa and Kersa) in Jimma Zone, located in south-western Ethiopia in Oromia region as shown in Figure 5.1. Populations in the *woredas* range from 180,000 to 270,000 in 2016.(16) Coffee production is an important source of revenue for residents of Gomma while Seka Chekorsa and Kersa residents engage mainly in small-scale cereal production.(16) As part of the tiered health care system in Ethiopia, Jimma Zone has two general hospitals, six district hospitals, 122 health centres and 566 health posts.(17) The lowest health system level functions at the *woreda* level (district) and consists of primary health care units (PHCUs). Each PHCU includes a health centre serving around 25,000 people and community-based health posts responsible for a population of 3,000-5,000. Regional level data indicate that in 2016, 48.6% of women surveyed in Oromia region in the DHS received no antenatal care and just 18.8% of women delivered at a health facility, placing the region among the poorer performing areas in the country.(3)

5.2.3.2. Data source

Data from a cross-sectional household survey, conducted prior to intervention roll-out (baseline survey) between October 2016 and January 2017 as part of a cluster-randomized controlled trial (ClinicalTrials.gov; NCT03299491), was used for this analysis. (18) Women living in the catchment area of 24 PHCUs within the study's three districts and who reported a pregnancy outcome (livebirth, stillbirth, miscarriage or spontaneous abortion) within 12 months of the baseline survey were eligible

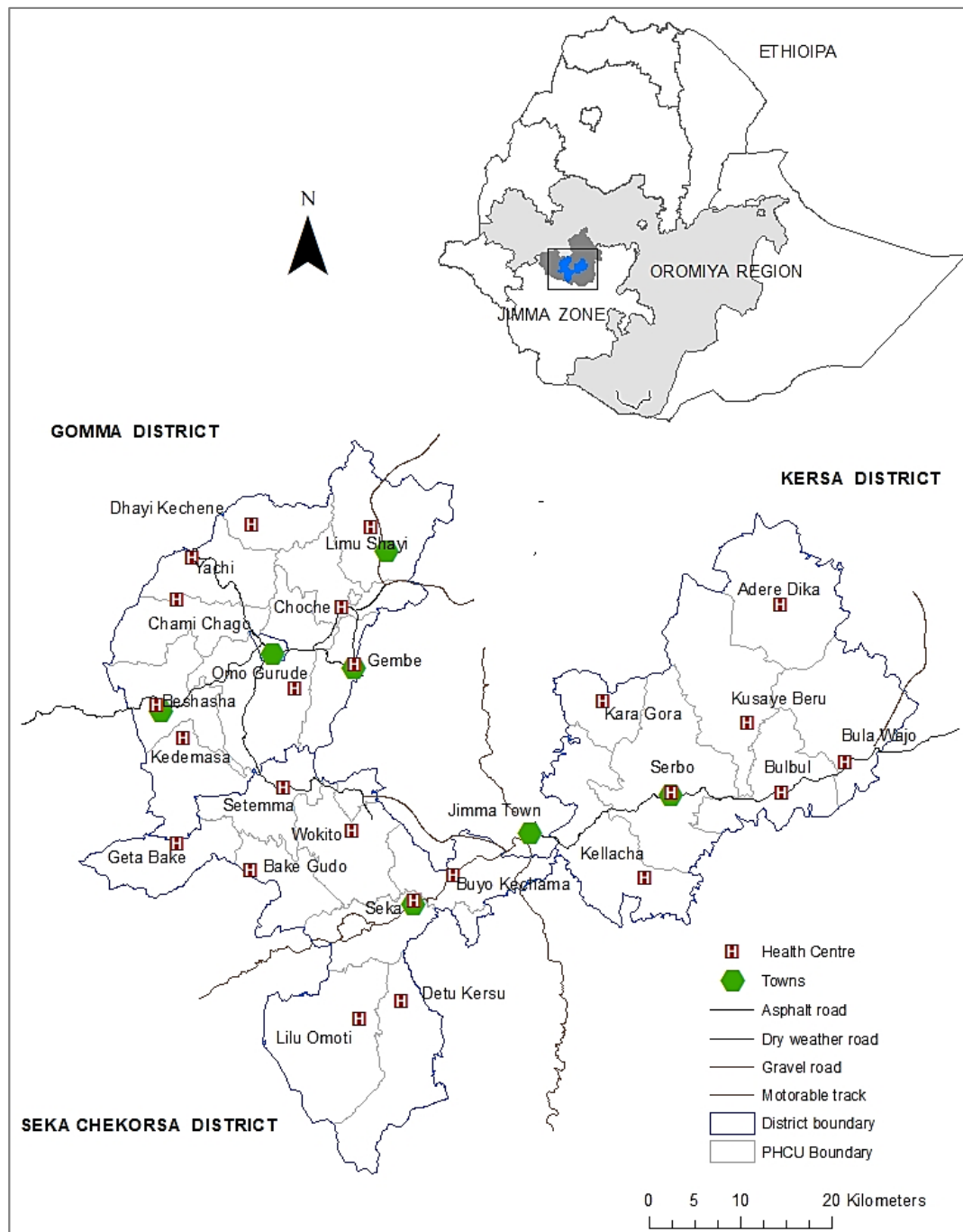


Figure 5.1. Map of the study area showing primary health care unit (PHCU) catchment area boundaries, enrolled households and locations of health centres within PHCUs created using ArcMap (ESRI, Redlands, USA) 10.6.1

to participate. Sample size (24 PHCU clusters with 160 women each) was calculated based on 80% power to detect an absolute difference of 0.17 in the proportion of institutional births (primary trial assuming a control arm proportion of 0.4 and using a two-sided alpha of 0.025 to account for two pairwise comparisons. Verbal informed consent was sought from all participants owing to low levels of literacy. Approximately 98.5% (n=3,784) of the randomly selected women were successfully enrolled and interviewed in either Afaan Oromo or Amharic by trained research assistants. Data were collected on sociodemographic characteristics and maternal healthcare service utilization using tablet computers programmed with surveys using Open Data Kit freeware.(19) GPS locations of households and health centres were also collected on tablet computers; GPS locations were available for 3,758 (97.9%) of the enrolled households.

5.2.3.3. Variables of interest

The analysis focused on four services across the continuum of maternal healthcare: antenatal care, maternity waiting home use, delivery care at health facilities, and postnatal care. As women's education levels and household wealth have previously been linked to access inequities (19), we adopted them for our analyses. Operational definitions of all the variables of interest are described in Table 5.1.

Table 5.1. Operational definitions of analysis variables used to describe maternal health care service use among women with a pregnancy outcome in 2016-2017 living in Jimma Zone, Ethiopia

Variable	Definition
Antenatal care	The proportion of women in the PHCU (or <i>kebele</i>) who report receiving any antenatal care during their last pregnancy (i.e at least one visit to a health centre or health post where antenatal care services are offered)
Maternity waiting home use	The proportion of women in the PHCU (or <i>kebele</i>) who report ever having used an MWH during their previous pregnancies.
Delivery care	The proportion of women in the PHCU (or <i>kebele</i>) who report giving birth to their last child at a health facility offering obstetric care (i.e health centre or hospital).
Postnatal care	The proportion of women in the PHCU (or <i>kebele</i>) who report receiving any postnatal care following the birth of their last child (i.e at least one postnatal care check-up within 6 weeks of delivery)
Education	The proportion of women in a PHCU (or <i>kebele</i>) who report having some formal education (i.e some primary, secondary or higher-level education).
Household wealth	The proportion of households in the PHCU (or <i>kebele</i>) who fall within the highest two household income quintiles (i.e fourth and fifth quintiles of household wealth) as determined using an asset-based principal components analysis.

Principal components analysis was used to create the household wealth variable using ownership of assets and animals, utilization of health insurance, presence of electricity supply, type of drinking water source, type of toilet present, and type of materials used for floor construction of the home. Using methods described by Vyas & Kumaranayake (21), socio-economic scores were generated for each household and then categorized into quintiles. The first quintile corresponds to poorest households while the fifth quintile corresponds to the least poor households.

5.2.3.4. *Exploratory analyses*

Frequencies and percentages of education and wealth levels in survey clusters were generated in STATA version 15 as part of descriptive analyses. Differences between survey clusters in the percentages of wealthy and educated households were then compared using a chi square test. P values less than 0.05 considered to be statistically significant.

Euclidean distances between households and the health centre within the PHCU catchment were calculated in kilometres for each PHCU using the *Generate Near Table* tool in ArcMap version 10.6.1. Distances were summarized using means, standard deviations and ranges and classified into three categories (<2km, 2-5km and >5km) to facilitate comparison between PHCUs using a chi square test.

Geographical variation in maternal healthcare service use was explored at the PHCU-level, the level at which maternal and other primary care services are coordinated and at the *kebele*-level, which is the smallest administrative unit and where health posts, staffed by two health extension workers (HEWs) are located. To this end, the proportion of women who reported using a given service during their last pregnancy within each geographical unit (PHCU or *kebele*) in the study area was calculated. Additionally, household-level binary data was used to explore variation in service use without constraining analyses within administrative boundaries. Instead, a maximum radius of 5km, at which we hypothesize interpersonal and social factors affecting service use could operate, was used. Other studies in similar settings have estimated a one-hour walking distance to be between 3km to 5km depending on the season and terrain.(21,22) District-level analyses were not feasible given the limited number of districts.

5.2.3.4.1. Variation in service use at PHCU level and correlation with household wealth and education

At the PHCU-level, choropleth maps were generated; choropleth maps present interval data superimposed over geographic units using colours and symbols to distinguish between intervals.(23) To explore utilization levels among marginalized population sub-groups (women from poor households and women with no education), education and household wealth were symbolized as separate layers

and superimposed to visualize correlations. Intervals for all variables were manually created based on what best suited the distribution of each variable, meaning that only qualitative comparisons can be made between services as intervals differ between services.

Each maternal health care service was assigned a different colour with darker shades indicating higher extents of service. Wealth and education indicators are overlaid using proportional symbols where larger circles correspond to higher levels. Administrative boundaries for PHCUs were created by dissolving boundaries of villages known to fall within the catchment area of the PHCU using the Dissolve tool in ArcMap. PHCU size varied from 53 square kilometres (sq km) to 186 sq km; the mean area was 108.5 sq km (standard deviation 39.6 sq km).

5.2.3.4.2. Spatial clustering in maternal healthcare service use at *kebele* level

To examine variation in service use at the *kebele* level, the presence of spatial autocorrelation for each service was first examined using the global Moran's I statistic. The results of this test indicate whether or not the spatial patterns observed in the data are random by looking at how each *kebele* deviates from the mean among neighbouring *kebeles*. Statistically significant and positive Moran's I indices indicate the presence of clustering (i.e a high degree of similarity in levels of service use between neighbouring *kebeles*) while negative values specify dispersion (i.e neighbouring *kebeles* have dissimilar values).(24) An inverse-distance-based spatial relationship conceptualization was selected for the process; this means that *kebeles* outside the threshold distance are not included in the computations. The threshold distance at which every *kebele* had at least one neighbouring *kebele* was determined to be 7.6 km. Of the 100 *kebeles* present in the study area, data were available for 96. An average of 48 women were enrolled per *kebele*. One *kebele* with less than five women enrolled was excluded as this number was considered to be too low for the analysis.

The next step was to pinpoint the location of clusters. The *Optimized Hot Spot Analysis* tool in ArcMap was used to identify where clustering was occurring. This tool relies on the Getis Ord G_i^* spatial statistic to uncover statistically significant hot spots (clusters of high service use) and cold spots (clusters of low service use). Clusters are considered statistically significant only if they are surrounded by similarly high or low values.(25) The optimal fixed distance band is determined by the tool for each service outcome by determining at what distance clustering is maximized. This was found to be 10 km for ANC, 7 km for MWH use and 19 km for delivery care. For PNC, a threshold distance of 7 km was used as no optimal distance was found using the clustering intensity method. The resulting output is a map of statistically significant hot (red) and cold (blue) spots presented at 99% (+/- 3 G_i^* values), 95% (+/- 2 G_i^* values) and 90% significance (+/- 1 G_i^* values) and corrected for multiple testing.

Finally, household-level data on women's reported service use were analysed using the Kulldorf spatial scan statistic in SaTScan 9.6. This spatial tool functions by running circular "scanning windows" of multiple sizes across the study space. The events observed within the window are compared to those expected under the null hypothesis of no difference inside and outside the window; a relative risk (RR) is generated which represents the ratio of events observed and expected within the window to those observed and expected in the study area. The formula used in SaTScan (26) is:

$$RR = \frac{c / E[c]}{(C-c) / (C - E[c])}$$

where c is the observed number of events within a potential cluster (window)

C is the total number of events in the dataset

The overall proportion of events in the study area were 84.3% for ANC, 6.6% for MWH use, 48.5% for delivery care and 39.0% for PNC. A relative risk greater than one would suggest proportion observed within the window is higher than expected while relative risks less than one suggest observed proportions are lower than expected. Bernoulli model was used due to the binary nature of the outcomes and the window radius set to a maximum of 5 km. The most likely cluster is identified as the window with the maximum likelihood, meaning it was least likely to have occurred by chance. Monte Carlo hypothesis testing is used to generate p-values where ranks of maximum likelihood of the observed dataset is compared to random datasets. A Secondary clusters are also identified and ranked according to the Likelihood Ratio Test statistic. (26)

5.2.4. Results

5.2.4.1. *Characteristics of PHCUs and sampled clusters*

The size of PHCUs varied, with total number of households ranging from 2,509 households to 11,791 households. There were also statistically significant differences (p -value <0.001) between the PHCUs in the percentage of educated women and wealthy (least poor) households. PHCUs with the highest proportion of educated women (69%) and wealthy households (81%) were located in Gomma district. Kusaye Beru in Kersa district had the lowest proportion of educated women (25%) while the PHCU with the lowest percentage of wealthy households was located in Seka Chekorsa (7%).

Sampled households were located an average of 4.2 km from health centres within their PHCUs with straight line distances ranging from just 100 meters to 18 km. There was a statistically significant difference in distances between the PHCUs (p value >0.001) (data not shown). Twelve PHCUs had over 30% of their households located more than five kilometres from the catchment health centre; Bula Wajo (73%), Bake Gudo (64%) and Kellacha (55%) had more than half the population located greater than

five kilometres from the catchment health centre (Figure 2). The majority of women (n=3,167, 87%) reported reaching health facilities by foot.

Table 5.2. Characteristics of PHCUs and sampled clusters in 2016 within Gomma, Seka Chekorsa and Kersa districts in Jimma Zone, Ethiopia

PHCU by district	PHCU characteristics ¹			n	Cluster characteristics			
	Total households	Total women	Health posts		Educated households n (%) ²	p value	Wealthy households ³ n (%)	p value
Gomma						<0.001		<0.001
Beshasha	7,556	8,026	5	154	92	59.7	124	80.5
Chami Chago	5,808	6,170	4	189	90	47.6	139	73.5
Choche	5,889	6,256	4	159	109	68.6	115	72.3
Gembe	5,242	5,568	4	130	74	56.9	84	64.6
Dhayi Kechene	2,509	2,665	2	159	85	53.5	57	35.9
Kedemasa	3,980	4,228	3	165	59	35.8	52	31.5
Limu Shayi	6,696	7,113	5	158	75	47.5	99	62.7
Omo Gurude	11,791	12,525	7	136	83	61.0	89	65.4
Yachi	4,921	5,227	3	152	74	48.7	113	74.3
Kersa								
Kusaye Beru	5,581	5,928	5	111	28	25.2	15	13.5
Bulbul	4,332	4,602	4	116	44	37.9	34	29.3
Adere Dika	4,813	5,113	3	161	42	26.1	39	24.2
Kara Gora	3,921	4,165	3	161	42	26.1	29	18.0
Kellacha	8,906	9,460	6	153	56	36.6	45	29.6
Serbo	10,666	11,330	7	242	96	39.7	57	23.6
Bula Wajo	5,636	5,987	3	166	48	28.9	43	25.9
Seka Chekorsa								
Bake Gudo	4,676	4,967	4	159	64	40.3	45	28.3
Detu Kersu	5,990	6,363	4	158	78	49.4	11	7.0
Geta Bake	3,483	3,699	3	160	81	50.6	38	23.8
Buyo Kechama	4,863	5,166	5	134	56	41.8	48	35.8
Lilu Omoti	9,525	10,118	6	152	63	41.5	47	30.9
Seka	5,119	5,438	6	222	98	44.1	61	27.5
Setemma	7,118	7,561	4	160	89	55.6	76	47.5
Wokito	6,109	6,489	4	127	57	44.9	53	41.7
Total	145,130	154,163	104	3,784	1,683	44.5	1,513	40.0

1 Obtained from the Jimma Zone Health Office records

2 Proportion of households within the cluster where women report having received some level of education (i.e., primary, secondary or higher) obtained from the baseline household survey conducted in 2016/2017.

3 Proportion of households within the cluster that fall in two least poor quintiles (4th and 5th) based on the asset-based wealth index scores obtained from the baseline household survey conducted in 2016/2017.

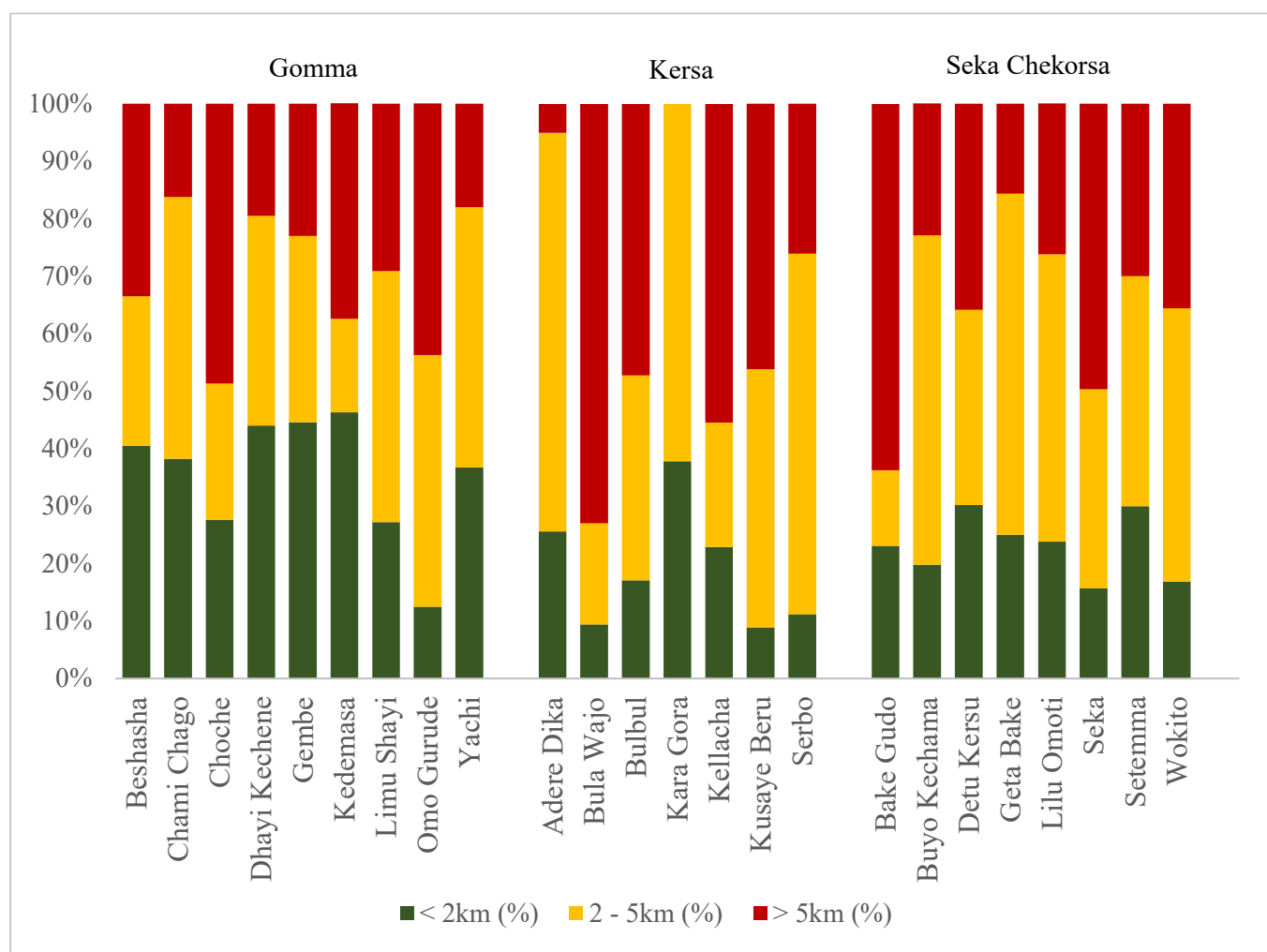


Figure 5.2. Percentages of surveyed households within 2 km, between 2-5 km and more than 5 km from health centre by PHCU and district in Jimma Zone, Ethiopia

5.2.4.1. Variation in service use at PHCU level and correlation with household wealth and education

As shown in Figure 5.3a, ANC use was generally higher among PHCUs with higher levels of wealthy households. PHCUs with high ANC use were mainly concentrated in the north-western part of the study area in Gomma district and parts of Seka Chekorsa. PHCUs with ANC use reported to be above 90% also had more than 60% of households in the upper two (least poor) wealth quintiles. Buyo Kechama and Seka were the exceptions with over 90% ANC use but having about half as many wealthy households (34% and 28% respectively) as similar performing PHCUs. Delivery care use (Figure 5.3c) had similar correlations to wealth as ANC use, with wealthier PHCUs displaying higher relative use of services and poorer PHCUs exhibiting lower utilization levels. However, there were a few notable exceptions where service use did not correspond to relative wealth. For example, Kusaye Beru (delivery care:43%) which had service use levels as low as that found in Bulbul (delivery care:41%) and Bake Gudo (delivery care:43%) but had half as many least poor households (least poor:14% vs. 29% and 28% respectively). Similarly, Setemma with almost half the households belonging to the wealthiest

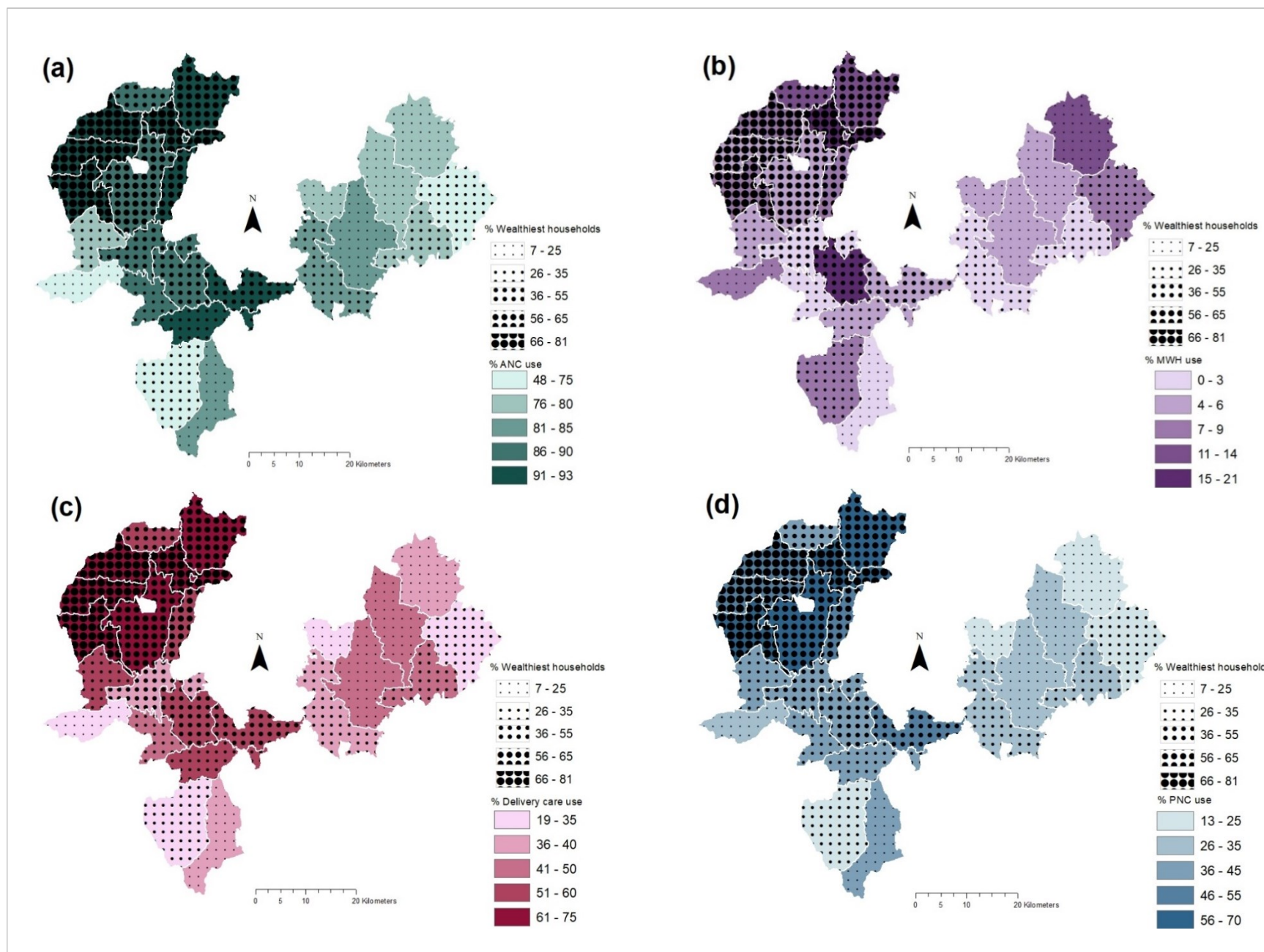


Figure 5.3. Choropleth maps highlighting correlation between household wealth and (a) ANC use (b) MWH use (c) Delivery care and (d) PNC use at PHCU-level

quintiles had delivery care use levels (delivery care:38%) that matched Detu Kersu (delivery care: 36%) where only 7% of households are wealthy. The correlation between lower wealth levels and low service use was particularly evident with PNC use patterns (Figure 5.3d) in PHCUs in Kersa district; 30% or less of the households were in the least poor groups and PNC use was well below average, ranging from 13% to 32%.

Correlation between household wealth and MWH use was more variable than for the other three services (Figure 5.3b); several PHCUs with more than 50% of households in the least poor group such as Chami Chago or Omo Gurude had utilization levels between 4-6% while PHCUs such as Adere Dika (MWH use: 13%) and Dhayi Kechene (MWH use: 14%) that were comparatively poorer had above average levels of use. However, PHCUs with under 30% of least poor households such as Bake Gudo or Detu Kersu had lower than average MWH use (<1%).

A trend similar to that observed with wealth was noted between service use and women's education as displayed in Figure 5.4. PHCUs in north-western segment of the study area generally had higher utilization levels of ANC, delivery care and PNC and education levels than the north-eastern part. In fact, the PHCUs with the highest utilization of services were consistently located in Gomma and the northern sector of Seka Chekorsa, near Jimma town, and also had relatively higher levels of women who reported some level of education. Once again, however, there were exceptions. For example, Geta Bake registered lower levels of service use despite having over 50% education levels which was higher than some of the better performing PHCUs north of it or indeed neighbouring Bake Gudo.

5.2.4.2. *Spatial clustering in maternal health care service use at kebele level*

The results of the global Moran's I tests pointed to the presence of spatial autocorrelation in the study area with respect to ANC use (Moran's I=0.15, p value=0.025), delivery care (Moran's I=0.17, p value=0.01), and postnatal care (Moran's I=0.31, p value <0.01), but not MWH use (Moran's I= -0.005, p value = 0.94). This means that there is clustering of *kebeles* with similarly high and/or low service utilization levels.

The locations of service utilization clusters identified using the Getis Ord Gi* spatial statistic are displayed in the panel of maps in Figure 5.5. Since no spatial autocorrelation was detected in MWH use, cluster detection was limited to the three other services. For ANC use, four *kebeles* in Bula Wajo PHCU and one in Adere Dika were found to be statistically significant cold spots (Figure 5.5a). This means that although there may have been other *kebeles* with similarly low ANC utilization levels in the study area, these four had low levels of use and were surrounded by similarly low performing *kebeles*.

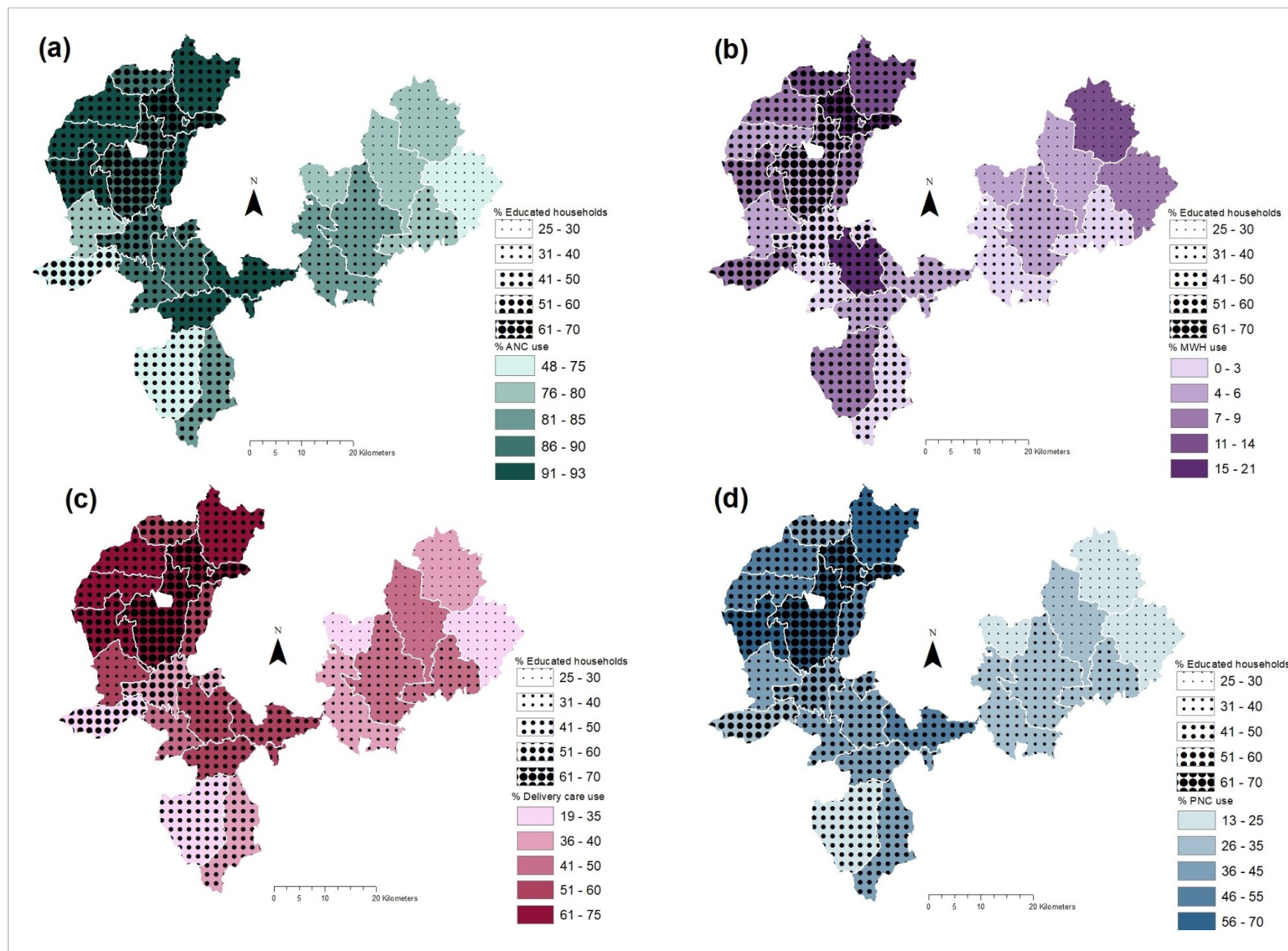


Figure 5.4.
Choropleth
maps
highlighting
correlation
between
women's
education
and
(a) ANC use
(b) MWH
use
(c) Delivery
care and
(d) PNC use
at PHCU-
level

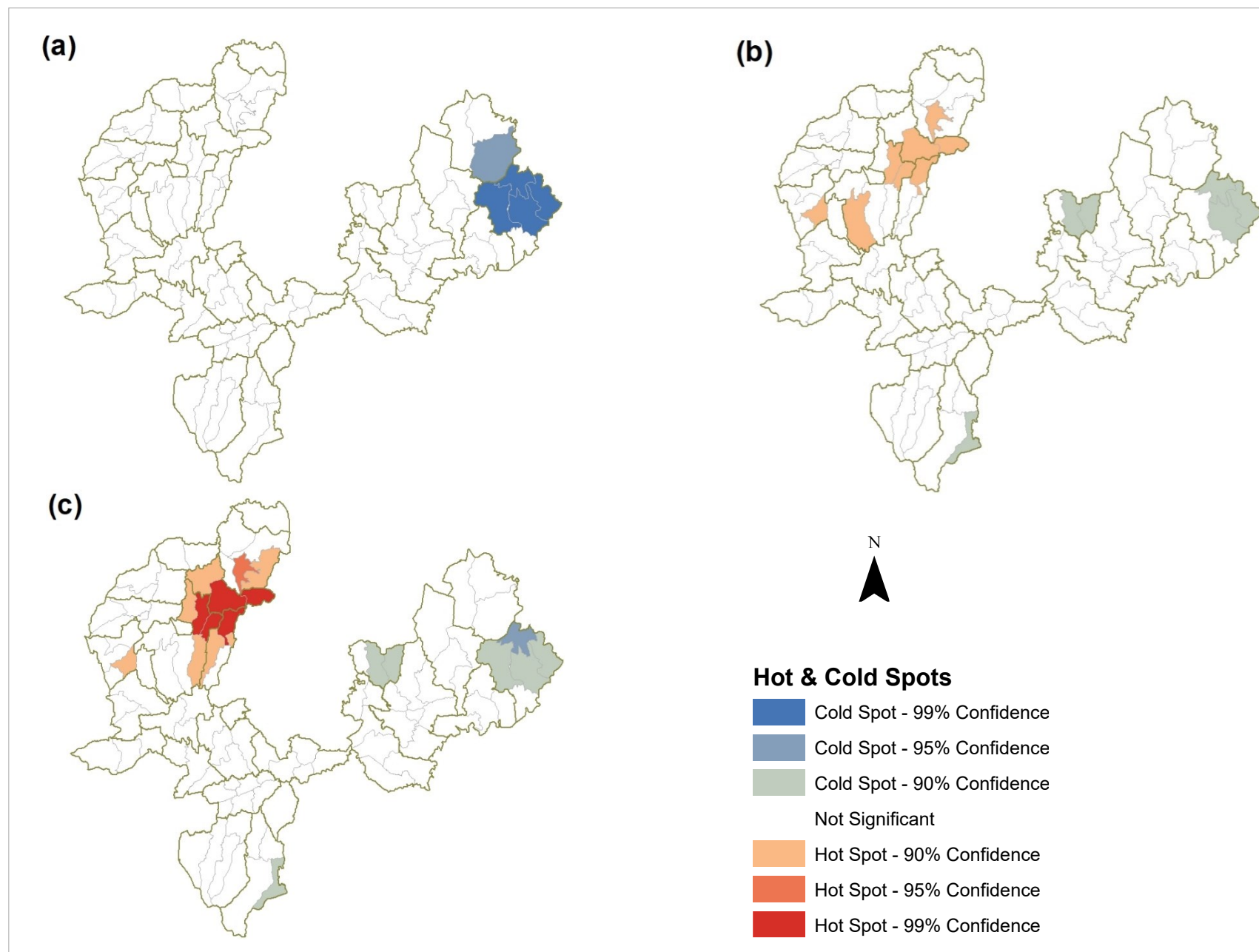


Figure 5.5. Hot and cold spots at *kebele*-level of (a) ANC (b) Delivery care use (c) PNC use in study districts

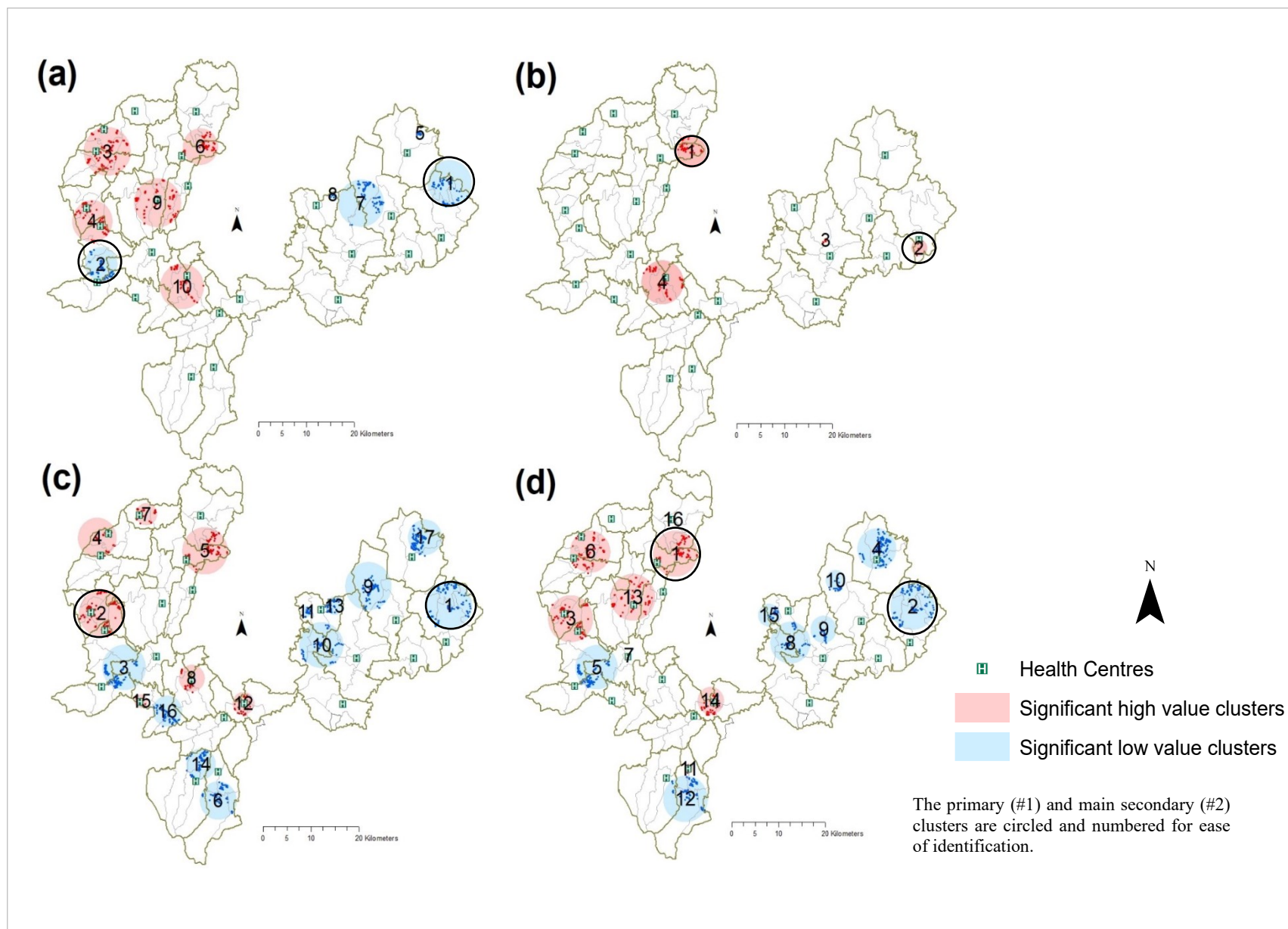


Figure 5.6.
Clusters within
kebeles of
(a) ANC use
(b) MWH use
(c) Delivery
care use and
(d) PNC use in
study districts

For delivery care, eight hot and six cold spots were found; hot spots were located in *kebeles* in Gomma PHCUs and cold spots in Kersa PHCUs (Figure 5.5b). *Kebeles* with hot spots all recorded delivery care use well above the study area average of 49% and all except two *kebeles* had utilization levels higher than the Gomma district level use (64%). Among cold spot *kebeles*, Sinkulle and Dogoso in Bula Wajo PHCU had very low delivery care use reported (7% and 2% respectively).

Kebele clusters for PNC use were almost identical to delivery care except that there were additional hot spots detected in Limu Shayi, Omo Gurude, Gembe and Choche PHCUs (Figure 5.5c). Among the 13 hot spots identified, eight had over 65% PNC use with 82% of women in Bulbulo reporting PNC use after the birth of their last child. Cold spots exhibited PNC use levels comparable to delivery care; once again *kebeles* in Bula Wajo PHCU had exceptionally low levels of PNC use ranging from 3% to 5%. The cold spot in Kora Wacho in Seka Chekorsa had PNC use at 10%.

Locations of statistically significant clusters detected for each service using the Kulldorf spatial scan statistic are shown in Figure 5.6. Details about the primary cluster (most likely cluster) and main secondary cluster are displayed in Table 5.3.

Table 5.3. Primary and main secondary household-level clusters of service use detected using Kulldorf spatial scan statistic.

	Cluster population	Observed use within cluster	Expected use within cluster	Relative Risk	p-value
Primary clusters					
Antenatal care	81	12	68	0.17	<0.0001
Maternity waiting homes	65	22	4	5.56	<0.0001
Delivery care	120	11	58	0.18	<0.0001
Postnatal care	133	102	52	2.04	<0.0001
Main secondary cluster					
Antenatal care	95	43	81	0.53	<0.0001
Maternity waiting homes	12	10	1	12.16	<0.0001
Delivery care	216	170	104	1.69	<0.0001
Postnatal care	116	7	45	0.15	<0.0001

A primary cluster of households was found from *kebeles* in Bula Wajo PHCU north of the health centre (Figure 5.6a) which exhibited lower than expected ANC use (Relative Risk [RR]=0.17, $p<0.0001$). The main secondary cluster for ANC use was located between Kedemasa and Geta Bake

PHCUs close to the Geta Bake health centre ($RR=0.53$, $p<0.0001$). A total of ten statistically significant clusters were detected for ANC use.

Elevated MWH use was also found, with a total of five high value use clusters detected. The primary cluster was located among households in Dinu and Tesso Sadecha *kebeles* (Figure 5.6b) in Choche PHCU ($RR=5.6$, $p<0.0001$). The main secondary cluster also of elevated MWH use was situated near Bula Wajo health centre ($RR=12.16$, $p<0.0001$).

The primary cluster detected for delivery care was a cold spot from households in low performing *kebeles* in Bula Wajo PHCU ($RR=0.18$, $p<0.0001$). Nine additional secondary cold spots and seven hot spots of delivery care were also found (Figure 5.6c). The main secondary cluster of elevated delivery care use was found among households around the Beshasha and Kedemasa health centres in Gomma district ($RR=1.69$, $p<0.0001$).

Finally, 16 statistically significant clusters were found for PNC use (Figure 5.6d). The most likely clusters of households (primary cluster) were found in *kebeles* in Limu Shayi, Choche and Gembe PHCUs which exhibited higher than expected PNC use ($RR=2.04$, $p<0.0001$). The main secondary cluster was of lower use situated in Bula Wajo PHCU ($RR=0.15$, $p<0.0001$). Additional information on all secondary clusters can be found in the supplementary table.

5.2.5. Discussion

This study demonstrated the existence of significant variation in levels of maternal healthcare service use at PHCU and *kebele* levels in Jimma Zone. It also found that PHCU-level variations in level of household wealth and women's education generally correlated with service utilization trends. However, several exceptions to this trend were noted where low utilization was registered in some locations with higher education or wealth or vice versa. This points to the need to explore spatial heterogeneity, i.e., the existence of regionally specific associations, to determine the relative importance of wealth and education as well as other factors in determining service use. Although several determinants of service use have been reported in the literature, including women's education (28–30), place of residence (30,31), or household wealth (30,32), these studies generally rely on statistical models that generate parameter estimates that are constant over space; this approach assumes that the influence of factors is the same at every location.(33) However, this exploratory study suggests that this may not always be the case and warrants further investigation.

Different patterns between service use and household wealth or women's education were also noted between PHCUs depending on the type of service. Whereas for ANC, delivery care and PNC the correspondence between service use and wealth or education was roughly similar, the effect of wealth on MWH use appeared to be less straight-forward. This may be because MWH use is moderated by need which is dependent on distance and access to transport. It is reasonable to assume that women living close to health facilities or who are able to easily travel would opt to go to a health facility when in labour obviating the need to stay at an MWH. Utilization may also be influenced by other factors such as type of occupation or access to social support.(34) This may be the case in Omo Gurude for instance, where despite having a higher percentage of wealthy (65%) and educated (61%) households and almost 45% of the population living more than 5km from a health centre, MWH use was slightly less than average.

While no causal inferences about correlations between service use and wealth or education can be made through this exploratory analysis, this work suggests that marginalized groups may exist in areas of low maternal healthcare service use in this rural area of Ethiopia. Similar results have been reported in neighbouring Kenya wherein counties with high rates of poverty and illiteracy had much lower levels of skilled birth attendance than counties with better socioeconomic indicators. Moreover, clear geographical differences in skilled birth attendance and child immunizations were noted on choropleth maps generated by the authors.(35)

The results from both global and local spatial statistics suggest that underlying spatial processes may be influencing maternal healthcare service utilization in the study area. The location-specific observed patterns indicate that areas with similar utilization tendencies were located close together. Several studies have reported differential utilization according to place of residence with rural areas falling short in antenatal (36), delivery (32,37,38) and postnatal care (39) use compared to urban areas. PHCU-level variation may also be reflective of differences in service delivery and quality. Qualitative evidence from Ethiopia suggested contrasting levels of collaboration between health extension workers (HEWs) and health centre staff, variable coordination between higher-level administrative bodies (district, zone and region) and use of available data for decision making at district level (40) which may contribute to differences observed in service use.

Investigating sub-national variation in health outcomes and access to health services has become a priority with the realization that equitable progress will only be achieved if populations that are under-served are identified and supported. Moreover, ensuring that maternal health services are able to “respond to local specificities of need...” is critical for ensuring equitably improved maternal health outcomes.(41) As a cross-sectional survey conducted in two urban slums in Lagos, Nigeria (that found J.Kurji PhD thesis (2021)

maternal mortality within neglected neighbourhoods to be almost double the state average) concluded, the use of sub-national data is urgently needed to enable targeted support based on identified gaps in coverage and access.(42)

The presence of spatial processes driving utilization at *kebele* level suggests that factors affecting access to maternal healthcare may operate at these levels and may require more focused community-level interventions. The Ethiopian health system is well-positioned to mount responses at this level via its network of community-based HEWs who are mandated to engage in health promotion and disease prevention activities. HEWs play an active role in improving access to maternal healthcare services through community education and provision of referrals. Correlations between HEW outreach activities and improvements in antenatal and postnatal care use trends have been demonstrated at village level; (43) home-visits conducted by HEWs have also been reported to increase the odds of ANC use and facility deliveries in Ethiopia.(44) HEWs also work closely with members of the Women's and Men's Development Army which have extensive reach at the *kebele* level through the model family platform. Model families are households that have successfully implemented changes to their households to improve family health and sanitation; they are expected act as positive influences at the neighbourhood level by encouraging similar change in others.(45)

5.2.5.1. Study limitations

A common concern with spatially aggregated data is ecological bias, which arises when associations found at group-level do not necessarily apply at the individual level, referred to as ecological fallacy.(46) However, household wealth and women's education have been shown to be important determinants of maternal healthcare service use at the individual level. What remains to be investigated is the location-specific variability in the relative importance of these equity dimensions and other determinants of service use. These exploratory analyses suggest that there is some spatial non-stationarity in these outcomes which can be assessed using local modelling techniques such as geographically weighted regressions. Future work aiming to investigate what factors drive heterogeneity of service use at sub-national level should account for the potential sensitivity of wealth indexes to the items included in their construction. (46)

Euclidean distances were calculated which, while being the simplest way to estimate distances, are often criticized for not accounting for geographic context such as terrain or the availability of roads. Despite this, Euclidean distances have been shown to perform comparatively well; they are proposed to be suitable for low resource settings where road-networks and land-cover data needed for cost-distances, are not easily available.(47)

In this exploratory analysis, which aimed to uncover spatial variation in service use by examining sub-national data, facility “by-passing” was not considered. “By-passing” is where women seek care for facilities other than the one closest to them.(48) While this does not affect PHCU-level estimates of service use or change areas with hot/cold spots, this could have implications for future work that aims to investigate location-specific determinants of use. Additionally, the dynamic nature of catchment areas in the context of a growing population, means that spatial patterns may also change with time. The introduction of a new health facility offering maternal healthcare that brings services closer to women may decrease cold spots. This highlights the need to integrate spatial analyses into routine health service monitoring to make it an effective decision-making tool for policymakers.

The use of community-based survey data rather than medical records minimizes the presence of selection bias which arises when analyses focus on those already able to access health services. Despite this, findings of this study can only be generalized to primarily rural, low-resource settings similar to the study area.

5.2.6. Conclusions

Mapping of core maternal healthcare service use indicators can serve as a “decision-making tool” and encourage “social accountability”.(49) This work demonstrated the existence of variation in utilization levels of maternal healthcare services at a sub-national level in rural south-western Ethiopia. More importantly, these sub-national differences closely reflected differences in poverty and women’s education levels, which have been found be linked to social inequities. In order to ensure equitable progress in health improvements across all segments of the population and to make effective use of resources, the integration of sub-national indicator mapping into routine health system performance monitoring systems may be helpful.

5.2.7. Declarations

5.2.7.1. *Ethics approvals and consent to participate*

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016).

5.2.7.2. *Availability of data and material*

Data used for this analysis will be provided by the authors upon reasonable request.

5.2.7.3. *Competing interests*

The authors declare that they have no competing interests.

5.2.7.4. *Funding*

This work was carried out with grants #108028-001 (Jimma University) and #108028-002 (University of Ottawa) from the Innovating for Maternal and Child Health in Africa initiative (co-funded by Global Affairs Canada (GAC), the Canadian Institutes of Health Research (CIHR) and Canada's International Development Research Centre (IDRC)); it does not necessarily reflect the opinions of these organizations.

5.2.7.5. *Authors' contributions*

JK conceptualized the study with input from MK. JK performed the analysis and was assisted by BT. JK wrote the first draft of the manuscript. All authors (MK, BT, VW, KBH, GB, RL, SM, LAG, MA) interpreted the findings, contributed to the development of the manuscript and approved the final manuscript.

5.2.8. Acknowledgements

We are grateful to the communities who have been generous with their time and thoughts and without whom this trial would not be possible. The authors would like to acknowledge research team members: Getachew Kiros, Abebe Mamo, Shifera Asfaw, Yisalemush Asefa, Gemechu Abene, Erko Endale, Nicole Bergen and Corinne Packer.

5.2.9. Article References

1. Bhutta ZA, Chopra M, Axelson H, Berman P, Boerma T, Bryce J, et al. Countdown to 2015 decade report (2000-10): taking stock of maternal, newborn, and child survival. *Lancet*. 2010;375(9730):2032–44.
2. Bhutta ZA, Reddy SK. Achieving Equity in Global Health. So Near and Yet So Far. *JAMA*. 2012;307(19):2035–6.
3. Central Statistical Agency, The DHS Program ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa and Rockville, Maryland; 2017.
4. Braveman P, Tarimo E. Social inequalities in health within countries: Not only an issue for affluent nations. *Soc Sci Med*. 2002;54(11):1621–35.
5. Marmot M, Friel S, Bell R, Houweling TA, Taylor S. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. 2008;372(9650):1661–9.
6. Sustainable Development Goals [Internet]. Available from: <http://www.un.org/sustainabledevelopment/health/>
J.Kurji PhD thesis (2021)

7. Alam N, Hajizadeh M, Dumont A, Fournier P. Inequalities in maternal health care utilization in sub-saharan African countries: A multiyear and multi-country analysis. *PLoS One*. 2015;10(4):e0120922.
 8. Say L, Raine R. A systematic review of inequalities in the use of maternal health care in developing countries: examining the scale of the problem and the importance of context. *Bull World Heal Organ*. 2007;85:812–9.
 9. Caliskan Z, Kilic D, Ozturk S, Atulgan E. Equity in maternal health care service utilization : a systematic review for developing countries. *Int J Public Health*. 2015;60:815–25.
 10. Fekadu M, Regassa N. Skilled delivery care service utilization in Ethiopia: Analysis of rural-urban differentials based on national demographic and health survey (DHS) data. *Adiktologie*. 2014;14(4):967–73.
 11. Birmeta K, Dibaba Y, Woldeyohannes D. Determinants of maternal health care utilization in Holeta town, central Ethiopia. *BMC Health Serv Res*. 2013;13(256).
 12. Abeje G, Azage M, Setegn T. Factors associated with Institutional delivery service utilization among mothers in Bahir Dar City administration, Amhara region: a community based cross sectional study. *Reprod Health*. 2014;11(22).
 13. Amano A, Gebeyehu A, Birhanu Z. Institutional delivery service utilization in Munisa Woreda, South East Ethiopia: a community based cross-sectional study. *BMC Pregnancy Childbirth*. 2012;12(1):105.
 14. Wako WG, Kassa DH. Institutional delivery service utilization and associated factors among women of reproductive age in the mobile pastoral community of the Liban District in Guji Zone, Oromia, Southern Ethiopia: a cross sectional study. *BMC Pregnancy Childbirth*. 2017;17(1):144.
 15. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes*. 2015;8(376).
 16. Oromiya Bureau of Finance and Economic Development. Oromiya Housing & Population Census. 2015.
 17. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2019.
 18. Kurji J, Kulkarni MA, Gebretsadik LA, Wordofa MA, Morankar S, Bedru KH, et al. Effectiveness of Upgraded Maternity Waiting Homes and Local Leader Training in Improving Institutional Births among Women in Jimma Zone, Ethiopia: study protocol for a cluster randomized controlled trial. *Trials*. 2019;20(671).
 19. Open Data Kit (ODK) [Internet]. [cited 2020 Aug 3]. Available from: <https://getodk.org/>
 20. Ruktanonchai CW, Ruktanonchai NW, Nove A, Lopes S, Pezzulo C, Bosco C, et al. Equality in Maternal and Newborn Health : Modelling Geographic Disparities in Utilisation of Care in Five East African Countries. 2016;1–17.
 21. Vyas S, Kumaranayake L. Constructing socio-economic status indices: How to use principal components analysis. *Health Policy Plan*. 2006;21(6):459–68.
 22. Blanford JI, Kumar S, Luo W, MacEachren AM. It's a long, long walk: accessibility to hospitals, maternity and integrated health centers in Niger. *Int J Health Geogr*. 2012;11(24).
 23. Tanser F, Gijssbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa : An exploration using a geographical information system. *Soc Sci Med*. 2006;63:691–705.
 24. Lawson AB, Banerjee S, Haining RP, Ugarte MD, editors. *Handbook of Spatial Epidemiology*. Boca Raton, Florida: CRC Press, Taylor & Francis Group; 2016.
- J.Kurji PhD thesis (2021)

25. O'Sullivan D, Unwin DJ. *Area Objects and Spatial Autocorrelation*. 2nd Ed. Geographic Information Analysis. Hoboken, New Jersey: John Wiley & Sons Ltd; 2010. 187–214 p.
26. ESRI. ArcGIS Tool Reference [Internet]. Available from: <https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics>
27. Kulldorff M. SaTScan User Guide for version 9.6 [Internet]. 2018 [cited 2019 Jan 11]. Available from: <http://www.satscan.org>
28. Tsegay Y, Gebrehiwot T, Goicolea I, Edin K, Lemma H, Sebastian MS. Determinants of antenatal and delivery care utilization in Tigray region, Ethiopia: a cross-sectional study. *Int J Equity Health*. 2013;12(30).
29. Mohan D, Gupta S, LeFevre A, Bazant E, Killewo J, Baqui AH. Determinants of postnatal care use at health facilities in rural Tanzania: multilevel analysis of a household survey. *BMC Pregnancy Childbirth*. 2015;15(282).
30. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. *BMC Pregnancy Childbirth*. 2014;14(161).
31. Melaku YA, Weldearegawi B, Tesfay FH, Abera SF, Abraham L, Aregay A, et al. Poor linkages in maternal health care services-evidence on antenatal care and institutional delivery from a community-based longitudinal study in Tigray region, Ethiopia. *BMC Pregnancy Childbirth*. 2014;14(418).
32. Gabrysch S, Campbell OMR. Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy Childbirth*. 2009;9(34).
33. Yang T-C, Shoff C, Noah A. Spatializing health research: what we know and where we are heading. *Geospat Health*. 2013;7(2):161–8.
34. Kurji J, Gebretsadik LA, Wordofa MA, Sudhakar M, Asefa Y, Kiros G, et al. Factors associated with maternity waiting home use among women in Jimma Zone , Ethiopia : a multilevel cross-sectional analysis. *BMJ Open*. 2019;9(e028210).
35. Keats EC, Akseer N, Bhatti Z, Macharia W, Ngugi A, Rizvi A, et al. Assessment of Inequalities in Coverage of Essential Reproductive, Maternal, Newborn, Child, and Adolescent Health Interventions in KenyaInequalities in Coverage of Essential Reproductive, Maternal, and Pediatric Health Interventions in KenyaInequalities i. *JAMA Netw Open*. 2018 Dec;1(8):e185152–e185152.
36. Adewuyi EO, Auta A, Khanal V, Bamidele D, Akuoko CP, Adefemi K, et al. Prevalence and factors associated with underutilization of antenatal care services in Nigeria : A comparative study of rural and urban residences based on the 2013 Nigeria demographic and health survey. *PLoS One*. 2018;13(5):e0197324.
37. Tey N-P, Lai S. Correlates of and Barriers to the Utilization of Health Services for Delivery in South Asia and Sub-Saharan Africa. *Sci World J*. 2013;2013(Article ID 423403).
38. Kyei-Nimakoh M, Carolan-Olah M, McCann T V. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. *Syst Rev*. 2017;6(110).
39. Langlois É V, Miskurka M, Zunzunegui MV, Abdul G, Daniel Z, Igor K. Systematic reviews Inequities in postnatal care in low- and middle-income countries : a systematic review and meta-analysis. *Bull World Health Organ*. 2015;93:259–70.
40. Fetene N, Linnander E, Fekadu B, Alemu H, Omer H, Canavan M, et al. The Ethiopian Health Extension Program and Variation in Health Systems Performance : What Matters ? *PLoS One*. 2016;11(5):e0156438.
41. Koblinsky M, Moyer CA, Calvert C, Campbell J, Campbell OMR, Feigl AB, et al. Quality J.Kurji PhD thesis (2021)

- maternity care for every woman, everywhere: a call to action. *Lancet*. 2016;388(10057):2307–20.
42. Anastasi E, Ekanem E, Hill O, Oluwakemi AA, Abayomi O, Bernasconi A. Unmasking inequalities : Sub-national maternal and child mortality data from two urban slums in Lagos , Nigeria tells the story. *PLoS One*. 2017;12(5):e0177190.
 43. Karim AM, Admassu K, Schellenberg J, Alemu H, Getachew N, Ameha A, et al. Effect of Ethiopia's Health Extension Program on Maternal and Newborn Health Care Practices in 101 Rural Districts: A Dose-Response Study. *PLoS One*. 2013;8(6):e65160.
 44. Afework MF, Admassu K, Mekonnen A, Hagos S, Asegid M, Ahmed S. Effect of an innovative community based health program on maternal health service utilization in north and south central Ethiopia : a community based cross sectional study. *Reprod Health*. 2014;11(28).
 45. Banteyerga H. Ethiopia's Health Extension Program: Improving Health through Community Involvement. *MEDICC Rev*. 2011;13(3):46–9.
 46. Spatial Aggregation and the Ecological Fallacy. In: Chapman Hall CRC Handbooks of Modern Statistical Methods. 2010. p. 541–58.
 47. Nesbitt RC, Gabrysch S, Laub A, Soremekun S, Manu A, Kirkwood BR, et al. Methods to measure potential spatial access to delivery care in low- and middle-income countries: a case study in rural Ghana. *Int J Health Geogr*. 2014;13(25).
 48. Kruk ME, Mbaruku G, McCord CW, Moran M, Rockers PC, Galea S. Bypassing primary care facilities for childbirth: A population-based study in rural Tanzania. *Health Policy Plan*. 2009;24(4):279–88.
 49. Matthews Z, Rawlins B, Duong J, Molla YB, Moran AC, Singh K, et al. Geospatial analysis for reproductive , maternal , newborn , child and adolescent health : gaps and opportunities. *BMJ Glob Heal*. 2019;4(e001702).

5.2.10. Supplementary material included in published paper

Secondary clusters detected

Cluster	Population	Observed use	Expected use	Relative Risk	p-value
Antenatal care					
3	267	256	225	1.15	<0.001
4	166	163	140	1.17	<0.001
5	15	3	13	0.24	<0.001
6	85	85	72	1.19	<0.01
7	79	47	67	0.70	<0.01
8	15	4	13	0.32	<0.05
9	108	106	91	1.17	<0.05
10	69	69	58	1.19	<0.05
Maternity waiting homes					
3	6	6	1	15.58	<0.001
4	87	22	6	4.13	<0.001
5	112	23	7	3.34	<0.05
Delivery care					
3	131	19	64	0.29	<0.001
4	138	113	67	1.74	<0.001
5	133	109	65	1.74	<0.001
6	62	5	30	0.16	<0.001
7	59	53	29	1.88	<0.001
8	40	38	19	1.98	<0.0001
9	78	12	38	0.31	<0.0001
10	58	7	28	0.25	<0.0001
11	24	0	12	0	<0.001
12	43	38	21	1.84	<0.01
13	63	11	31	0.36	<0.01
14	69	13	33	0.38	<0.01
15	32	29	16	1.88	<0.01
16	92	22	45	0.49	<0.05
17	110	29	53	0.54	<0.05
Postnatal care					
3	180	123	70	1.82	<0.0001
4	146	18	57	0.31	<0.0001
5	131	17	51	0.32	<0.0001
6	221	132	86	1.58	<0.0001
7	18	18	7	2.58	<0.001
8	48	2	9	0.11	<0.001
9	39	1	15	0.07	<0.01
10	30	0	12	0	<0.01
11	31	26	12	2.17	<0.01
12	97	15	38	0.39	<0.01
13	92	59	26	1.67	<0.05
14	58	41	23	1.84	<0.05
15	32	1	13	0.08	<0.05
16	20	18	8	2.32	<0.05

Chapter 6. How do local contextual differences change what influences maternal healthcare service use?

6.1. Article preface

This chapter built on the findings of the exploratory spatial analyses reported in Chapter 5 which revealed sub-national variation in maternal healthcare service use at PHCU and *kebele* levels. To then explore how local context could change what explanatory factors took precedence in influencing service use, I used geographically weighted regression models. These models allow estimation of local associations at finer spatial scales than typically considered.

6.1.1. Author contributions

I conceptualized the research questions and selected the analytic methods to meet my research objectives. I analysed the data in MGWR 2.2 (software) and received feedback on the methods and results from Dr. Manisha Kulkarni (thesis supervisor), Dr. Monica Taljaard (thesis advisory committee (TAC) member) and Dr. Ziqi Li (University of Illinois collaborator on the article). During the initial stages of analyses, I attempted to use GWR4 software and received helpful advice from my co-author Charles Thickstun who had previous experience with it. However, during my efforts at troubleshooting software issues I was introduced to MGWR 2.2 (through correspondence with Dr. A. Stewart Fotheringham) which proved to be more suitable for my work. I wrote the first draft of the manuscript and made revisions to it based on feedback from all co-authors as well as Dr. Ronald Labonté (co-supervisor), Dr. Gail Webber (TAC member) and Dr. Vivian Welch (TAC member).

6.1.2. Associated appendices

None

6.1.3. Ethical approvals

Ethics approval for the overall study was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Ethics approval for my doctoral research was obtained from the University of Ottawa Health Sciences and Science REB (File No: H02-18-02).

6.1.4. Article citation

Kurji, J., Thickstun, C., Bulcha, G., Taljaard, M., Li, Z., Kulkarni M.A. Spatial variability in factors influencing maternal health service use in Jimma Zone, Ethiopia: a geographically-weighted regression analysis. *BMC Health Serv Res* (2021) (in press)

6.2. Article content

Article title: Spatial variability in factors influencing maternal health service use in Jimma Zone, Ethiopia: a geographically-weighted regression analysis

Authors:

Jaameeta Kurji

School of Epidemiology and Public Health, University of Ottawa

Charles Thickstun

School of Epidemiology and Public Health, University of Ottawa

Gebeyehu Bulcha

Jimma Zone Health Office, Oromia Region, Ethiopia

Monica Taljaard

Ottawa Hospital Research Institute

Ziqi Li

Department of Geography & Geographic Information Science, University of Illinois

Manisha A. Kulkarni

School of Epidemiology and Public Health, University of Ottawa

6.2.1. Abstract

Background: Persisting within-country disparities in maternal health service access are significant barriers to attaining the Sustainable Development Goals aimed at reducing inequalities and ensuring good health for all. Sub-national decision-makers mandated to deliver health services play a central role in advancing equity but require appropriate evidence to craft effective responses. We use spatial analyses to identify locally-relevant barriers to access using sub-national data from rural areas in Jimma Zone, Ethiopia.

Methods: Cross-sectional data from 3,727 households, in three districts, collected at baseline in a cluster randomized controlled trial were analysed using geographically-weighted regressions. These models help to quantify associations within women's proximal contexts by generating local parameter estimates. Data subsets, representing an empirically-identified scale for neighbourhood, were used. Local associations between outcomes (antenatal, delivery, and postnatal care use) and potential explanatory factors at individual-level (ex: health information source), interpersonal-level (ex: companion support availability) and health service-levels (ex: nearby health facility type) were modelled. Statistically significant local odds ratios were mapped to demonstrate how relevance and magnitude of associations between various explanatory factors and service outcomes change depending on locality.

Results: Significant spatial variability in relationships between all services and their explanatory factors ($p < 0.001$) was detected, apart from the association between delivery care use and women's decision-making involvement ($p = 0.124$). Local models helped to pinpoint factors, such as danger sign awareness, that were relevant for some localities but not others. Among factors with more widespread influence, such as that of prior service use, variation in estimate magnitudes between localities was uncovered. Prominence of factors also differed between services; companion support, for example, had wider influence for delivery than postnatal care. No significant local associations with postnatal care use were detected for some factors, including wealth and decision involvement, at the selected neighbourhood scale.

Conclusions: Spatial variability in service use associations means that the relative importance of explanatory factors changes with locality. These differences have important implications for the design of equity-oriented and responsive health systems. Reductions in within-country disparities are also unlikely if uniform solutions are applied to heterogeneous contexts. Multi-scale models, accommodating factor-specific neighbourhood scaling, may help to improve estimated local associations.

6.2.2. Background

Policies to reduce maternal and infant mortality often target improving utilization of essential maternal health services including antenatal, delivery, and postnatal care (PNC). Linking women and their newborns to care provides opportunities to detect and manage potential complications early on.(1) Reported use of these essential services has steadily been increasing in low- and middle-income countries over the last few decades.(2,3) However, use of delivery and postnatal services has generally been lagging behind antenatal care (ANC).(4,5)

In Ethiopia, women reported 27% ANC, 5% delivery care and 2% PNC use in 2000(6); by 2019, national levels had reached 74%, 48%, 34% respectively.(7) However, substantial within-country variation has been noted with several regions recording utilization levels below the national average in all three services. In order to meet Sustainable Development Goal targets 3.1 and 3.2, which tackle maternal and child mortality (8), variation in service use at sub-national levels needs to be addressed to ensure equitable progress. More importantly, understanding how local contexts change the prominence of factors affecting use is necessary to create policy strategies that are responsive to local needs and that make effective use of resources.

A range of individual characteristics (such as attitude towards delivery care), inter-personal factors (like women's involvement in decision-making), and household factors (such as wealth) have

been reported to influence maternal health service use.(9–14) However, these associations are typically quantified using regression models that assume relationships are constant across the entire study area (stationary relationships). Estimates generated from these “global models” represent averages that can mask important variation between localities.(15) Moreover, the presence of spatial dependence (where locations exhibit values that are similar to neighbouring locations) leads to spatially autocorrelated residuals that would violate the assumption of independent and identical error terms on which global models operate.(16)

Exploratory work from three districts in Jimma Zone, Ethiopia, found evidence for spatial autocorrelation in the use of all three essential maternal health services.(17) Clusters with either higher (hotspots) or lower (cold spots) than expected levels of service use were identified at primary health care unit (PHCU)-, *kebele*- (village) and sub-*kebele* levels. This variability in service utilization may be indicative of underlying differences between localities in both the types of factors that are important for service use as well as the magnitude of associations. In fact, the impact of community influences on maternal health service use has also been previously discussed in qualitative studies.(18,19) Differences in neighbourhood wealth levels, norms around permission to visit health facilities, community views on giving birth at home or perceptions about quality of care developed through experiences of social network members can all contribute to regional variability in service use.(18,19) Contrasts in terrain and road access are also possible across different regions. If spatial mechanisms, where relationships depend on locality, have a role to play in observed patterns of service use, this needs to be appropriately explored to identify underlying factors.

The objective of this analysis, therefore, is to characterize non-stationarity in associations between explanatory factors and use of essential maternal healthcare services in Jimma Zone using geographically weighted regression models.

6.2.3. Methods

6.2.3.1. *Study setting*

Ethiopia is situated in north-eastern Africa and has a total land area of over one million square kilometres.(20) Altitudes range between 110 below sea level around the Denakil Depression to more than 4,600 metres above sea level in the Simien Mountain ranges.(20) Jimma Zone is located in the southwest of the country within Oromia region. Administratively, Ethiopia has nine regional states which are further divided into zones and then *woredas* (districts) that comprise several *kebeles* (villages). The lowest level of the tiered health system operates at *woreda* level where PHCUs exist. PHCUs comprise a health centre that typically offers ANC, PNC, and basic emergency obstetric services. Each PHCU also has several community-based health posts that serve between 3,000-5,000

people and are staffed by health extension workers (HEWs) responsible for health promotion and preventive care in the community.(21) The Jimma University and Shenen Gibe general hospitals, which both provide comprehensive emergency obstetric care, are located in Jimma town.

This study was conducted in Gomma, Kersa and Seka Chekorsa districts. While agriculture dominates income generation in all three study districts, Gomma has substantial coffee production which is an important income source for many households.(22) Altitude ranges between 1,500 meters and 2,700 meters across the three districts. In 2016, there were approximately 56,700 households in Gomma, 52,300 households in Seka Chekorsa, and 43,900 households in Kersa district.(23)

The data for this study were obtained from a cross-sectional, baseline household survey conducted as part of a cluster-randomized controlled trial to evaluate the effectiveness of upgraded maternity waiting homes and local leader training in improving utilization of maternal health services. Baseline data were collected between October 2016 and January 2017. Details about the trial are available in the published protocol.(24) Briefly, we randomly assigned 24 PHCUs (clusters) in a 1:1:1 ratio to one of the two intervention arms or to usual care. Repeat cross-sectional surveys at baseline (prior to intervention roll-out) and endline were used to collect data from random samples of 160 women per cluster during each survey round. Women were eligible if they reported a pregnancy outcome (livebirth, stillbirth, miscarriage or abortion) up to 12 months prior to each survey. The number of women interviewed were 3,784 (98.5% response rate) at baseline.

Data and GPS locations (collected using tablet computers) were available for 3,727 households (98% of enrolled households) from 96 *kebeles*. GPS locations were also collected for all 24 health centres. Locations were mapped using ArcGIS Pro (ESRI, Redlands, USA) and projected into Adindan UTM Zone 37N prior to analysis. Administrative boundary, town location and road network data were obtained from the Jimma Zone Health Office. A map of the study area created in ArcGIS Pro is included in Figure 6.1.

6.2.3.2. *Variables of interest*

Women's self-reported utilization of ANC, delivery care, and PNC services for their last pregnancy/birth were the main outcomes of interest. These were constructed as binary variables at the individual woman level. ANC use was defined as whether or not women reported at least four ANC contacts with service providers during their last pregnancy at a health post, health centre or hospital, where these services are normally provided. Delivery care use was defined as whether or not women reported giving birth to their last child at a health centre or hospital, where basic emergency obstetric

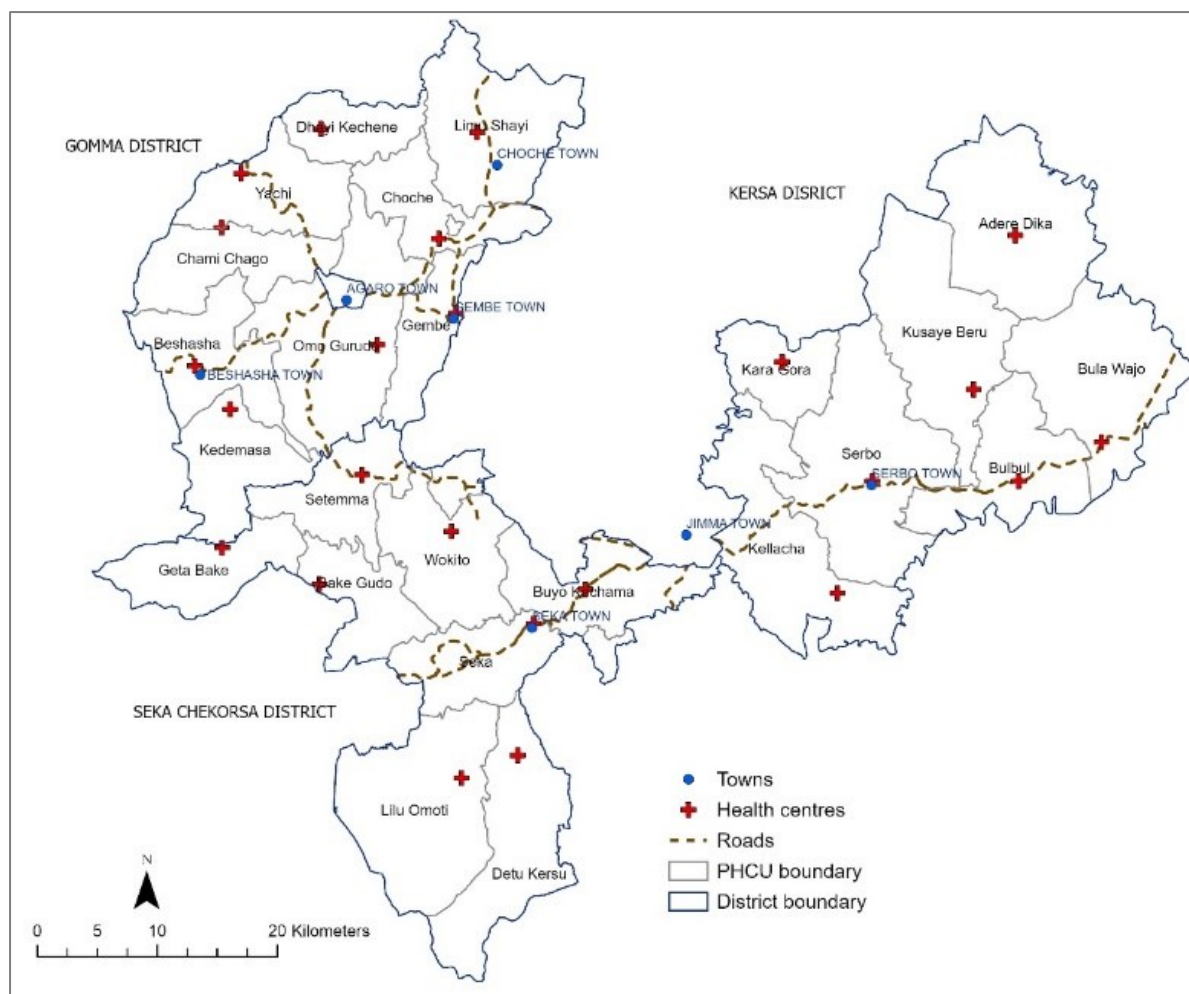


Figure 6.1. Map of the study area showing locations of health centres in PHCUs, main towns, roads, PHCU and district boundaries created in ArcGIS Pro (ESRI, Redlands, USA)

care is usually available. PNC use was defined as whether or not women reported receiving a check from a health worker at least one hour after giving birth to their last child. The one-hour cut-off was used to distinguish between intrapartum and postpartum care which has been reported to be conflated by women.(25) Levels of service use among women in the baseline survey were 47% for at least four ANC contacts and, 49% for delivery care and 39% for PNC.(26)

Candidate explanatory variables hypothesized to affect service use were identified based on the literature (9–14) and field experience. These were broadly categorized into individual woman characteristics, interpersonal or household elements and, health system-related considerations (Supplement 1: conceptual model). Factors hypothesized to be associated with all three services were: woman's education, health information source, danger sign awareness, prior service use, household wealth, woman's involvement in decision making, parity, home visits by HEWs and type of nearby health facility. Additionally, for ANC and delivery care use, perceived need for delivery care services,

birth preparedness and whether or not the pregnancy was planned were considered important; availability of companion support was expected to be more relevant for delivery and postnatal care. Mode of delivery was expected to be an important factor associated with PNC use.

Frequencies and percentages (for categorical variables) and summary statistics (such as mean and standard deviation) for the continuous variable (parity) were generated to describe the study population.

Health system factors such as quality of care are important, but since they are common across entire PHCUs they are unlikely to exhibit sufficient variability at the local level required for geographically weighted regression (GWR) models. Distance between households and health centres was also not included in the models as it could confound GWR results which employ distance-based analyses.(26) Finally, husband characteristics such as education level and risk perceptions around complications among both women and their husbands were not included in the models since missing data reduced available sample size and could introduce selection bias. Definitions for explanatory variables hypothesized to be important factors influencing service use are provided in Supplement 2.

6.2.3.3. Global regression models and presence of spatial dependencies

Before exploring spatial variation in relationships, the presence of spatial dependency needs to be established. This is usually done by testing the residuals from global models for the presence of spatial autocorrelation. Random effects multivariable logistic regression was conducted for each outcome (i.e., ANC, delivery care, PNC) with relevant candidate explanatory factors specified as fixed effects and PHCUs specified as random effects to account for intracluster correlation. Analysis was conducted in Stata version 15 (StataCorp, College Station, USA) and odds ratios with corresponding 95% confidence intervals were reported for each explanatory variable. These global estimates represent the mean values across the entire study area.

Deviance residuals were then generated and tested for the presence of spatial autocorrelation using Global Moran's I spatial statistic in ArcGIS Pro. Moran's I index generally ranges from -1 to 1; positive indices imply a clustering of similar values whereas negative indices are suggestive of more dispersed patterns.(27) A statistically significant Moran's I index would imply that a spatial correlation structure exists in the residuals that needs to be explored using models that can integrate this spatial dependence.

6.2.3.4. Exploring locally varying relationships using geographically weighted regression models

Geographically weighted regressions are an extension of conventional regression models that permit the estimation of coefficients for each location of interest (local estimates). In this way they can quantify non-stationary relationships which vary across space. The process is rooted in the first law of Geography which asserts that neighbouring objects are more closely related than more distant objects.(28) As shown below, parameter estimates for k independent variables are estimated for each location i , in this case households, specified by coordinates (u_i, v_i) (15):

$$\log\left(\frac{E(y_i)}{1-E(y_i)}\right) = \beta_o(u_i, v_i) + \sum_k \beta_k(u_i, v_i)x_{ik} + \varepsilon_i$$

The “local” parameter estimates are generated using subsets of data points that are considered to be neighbours of household i . Neighbourhood is defined using spatial kernels and bandwidth parameters. The kernel is a proximity weighting function while the bandwidth is a measure of the distance decay in the kernel.(15) Whereas global models assign the same weight to all household data points, kernels used in GWRs assign more weight to nearby households.

GWR analysis was conducted in MGWR 2.2.(29) An adaptive, bi-square function, shown below, was used as the kernel, where weights assigned to neighbouring households (j) decrease according to a near-Gaussian curve up to the bandwidth (b), after which they are assigned a weight of zero.(15)

$$w_{ij} = [1-(d_{ij}/b)^2]^2 \text{ if } j \text{ is an } n\text{th nearest neighbour}$$

d_{ij} is the distance between i and j

In this way, the weights determine the level of contribution each household makes to the local model calibration process.(15) An adaptive rather than fixed kernel was selected to ensure that all local model calibration subsets had an adequate number of households. Fixed kernels can result in local estimates with large standard errors in areas with fewer data points when data points are not evenly distributed across the study area.(15)

Optimization procedures are recommended when selecting bandwidths (15) as GWR estimates are sensitive to bandwidth choice. Large bandwidths may be unable to capture local variation and can return coefficients close to global model estimates. On the other hand, small bandwidths can result in high variability as coefficients are overly dependent on nearby points.(15) The Golden Section Search optimization technique was used to identify the optimal bandwidth that minimized the corrected Akaike Information Criterion (AICc).(15) Optimal bandwidths were determined to be 927 households (872-

2304) for ANC, 1459 households (1247-1573) for delivery care and 1560 households (1443-2296) for PNC.

6.2.3.5. *Model diagnostics and selection of the final local model*

The potential for multicollinearity between local coefficients has been previously described as a concern for GWRs.(30) However, subsequent simulation studies with large sample sizes ($\geq 1,000$) have demonstrated that GWRs estimates are not affected even in the presence of moderate global collinearity.(31) The results of diagnostic tests to check for multicollinearity in local parameter estimates, including condition numbers, local variance inflation factors (VIFs) and variance decomposition proportions (VDPs) were inspected nevertheless. Condition numbers greater than 30, VIFs greater than 10 and VDPs greater than 0.5 generally indicate a strong presence of multicollinearity.(32–34) Education and nearby health facility type were, thus, removed from ANC and PNC models respectively. The final combination of explanatory factors retained in the local models had no evidence of local multicollinearity;

A test for spatial variability was also run to identify which relationships were significantly non-stationary. The null hypothesis of this test is that the association of the explanatory factor with the outcome is globally fixed; a Monte Carlo approach is used to generate an experimental distribution of the variance of local parameters for each explanatory factor to which the actual variance is compared.(15)

Statistically significant estimates identified using adjusted p-values from the pseudo t-tests were exponentiated and mapped as odds ratios to visualize non-stationary relationships. Under pseudo t-tests, t-values are computed as a ratio between the estimate and its standard deviation and compared to a critical t-value that is adjusted for multiple testing using a Bonferroni-style correction adapted for GWRs.(15,35) The adjusted margin of error (α) was 0.005 for ANC, 0.009 for delivery care and 0.010 for PNC. Significant estimates were mapped in colour using natural breaks with darker shades indicating higher magnitude, while non-significant estimates were mapped in grey. Only qualitative comparisons can be made between maps for the three services as association estimates are classified differently for the same explanatory factors.

The relative performance between the global and local models was compared by inspecting the respective AICc for each model.(33) The lower AICc obtained for local models compared to global models indicate that the former had the “best fit to the data”(15) and, was therefore, a more desirable option for all three service outcomes. Finally, the residuals from the GWR models were tested using Global Moran’s I to see if there were any remaining spatial autocorrelation structures.

6.2.4. Results

6.2.4.1. Characteristics of the study population

Most women in the study area were housewives and about 45% had completed some level of education (Table 6.1). About half the women identified nurses as sources for birth-related information. While the majority of women were aware of at least one danger sign associated with pregnancy as well as birth, almost 60% were unaware of postpartum danger signs. In terms of prior maternal health service

Table 6.1. Frequencies, percentages, district- and PHCU-level ranges of explanatory factors

Characteristic	Frequency (n=3,727) (%)		District- level range (n=3) (%)	PHCU-level range (n=24) (%)
Individual factors				
Education level				
None	2,068	(55.5)	47 – 68	31- 73
Primary/secondary/higher	1,659	(44.5)	32 - 53	27 - 69
Occupation				
Housewife	2,884	(77.4)	76 – 80	67 - 90
Formal occupation	843	(22.6)	21 – 24	10 - 33
Danger sign awareness				
Aware of pregnancy danger signs	2,784	(74.7)	74 - 75	60 - 93
Aware of delivery danger signs	2,959	(79.4)	78 – 81	67 - 92
Aware of postpartum signs	1,548	(41.5)	40 – 43	29 – 61
Nurse as information source				
Health-related information ¹	1,543	(41.4)	37 - 47	15 - 53
Birth-related information	1,874	(50.3)	45 – 56	18 – 66
Service use				
History of ANC use ¹	2,070	(56.1)	50 – 65	21 – 83
ANC use for last child	1,756	(47.1)	38 - 55	26 - 62
History of delivery care use ¹	1,165	(31.6)	21 – 43	11 - 51
Delivery care use for last child	1,835	(49.0)	35 - 64	19 - 72
Attitude towards delivery care				
Unnecessary for experienced women	239	(6.5)	6 -7	1 - 16
Assisted delivery mode ¹	187	(5.0)	4 – 6	1 – 11
Household or inter-personal factors				
Wealthiest household group	1,184	(31.8)	15 – 53	6 – 68
Companion support available	2,907	(78.0)	70 – 86	5 – 53
Involved in decision making				
About delivery site	2,916	(78.2)	76 – 81	54-84
Health-related issues	2,656	(71.3)	67 - 75	59 - 91
Pregnancy planned	2,438	(66.1)	56 -73	42 – 81
Engaged in birth preparedness and planning	2,520	(67.6)	61 - 72	16 – 52
Health system factors				
Home visit by HEW	1,251	(33.6)	23 – 39	7 - 49
Nearby health facility type/level				
Hospital/health centre	1,751	(47.5)	42 – 54	28 – 74

¹ Denominators differ: *Nurse as source of health* information, data available for n=3,721 (99.8%) women only. *History of ANC use*, data available for n=3,688 (98.7%) women only. *History of delivery care use*, data available for n=3,682 as n=45 women were first time mothers for whom history of delivery care was not applicable. *Assisted delivery mode*, data available for n=3,714 women. n=11 had abortion outcomes and, therefore, delivery mode was not applicable while n=2 had missing data

use, close to 60% of women had used ANC services for past pregnancies, but only half as many reported prior delivery care use. Almost all women felt delivery care was necessary for all women (94%) and most had companion support available (78%), were involved in decisions about delivery site (78%) and prepared for birth (68%).

When variation of these factors was examined across districts, some differences were noted in education levels, prior service use, home visits by HEWs and the type of the closest health facility. Variation across districts in household wealth was notable, with 53% of Gomma residents falling within the least poor groups but only 15% belonging to these groups in Kersa district. Variability was also present between PHCUs, both within and across districts, and was the case for almost all potential explanatory factors. Using wealth as an example, the percentage of least poor households ranged from only 6% in Kusaye Beru PHCU (Kersa district) to 30% and 68% in Beshasha and Dhayi Kechene PHCUs respectively (Gomma district) (data not shown).

6.2.4.2. Global associations in service use identified by statistical regression models

Prior use of a maternal health service was the only factor that was strongly associated with current use of all three services (Table 6.2). Information source, household wealth and home visits by HEWs were found to be significantly associated with both ANC and delivery care but not PNC. Additionally, attitude towards delivery care, preparing for birth and type of nearby health facility, that were not hypothesized to be relevant for PNC use and, thus not included in the PNC model, were significantly associated with the other two services. Being involved in decision making, lower parity and the pregnancy being planned were important for ANC use while having an assisted delivery was significantly associated with PNC use. As hypothesized, having companion support was favourably associated with both delivery and postnatal care use. Awareness of danger signs was not a significant factor associated with delivery care use. Evidence of spatial autocorrelation in global model residuals was detected for all three services ($p < 0.001$) (results not shown).

6.2.4.3. Local variation in associations of service use revealed by GWR models

Variation in magnitude of local parameter estimates was visually apparent for all three service outcomes across most explanatory variables. However, whether or not local associations were statistically significant, the strength of the association, and at what scale the relationships appeared to vary, depended on the explanatory factor, service outcome and locality under consideration.

Table 6.2. Results from global random effects logistic regression analysis of antenatal, delivery and postnatal care use

Potential explanatory factor	Antenatal care (n=3,687) ¹		Delivery care (n=3,681) ¹		Postnatal care (n=3,708) ¹	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
Individual factors						
Education level						
None	-		Reference		Reference	
Primary/secondary/higher	-		0.77	(0.63,0.93)	1.09	(0.90, 1.33)
Pregnancy danger signs						
Not aware	Reference		-		-	
Aware	1.21	(1.02,1.44)	-		-	
Delivery danger signs						
Not aware	-		Reference		-	
Aware	-		1.22	(0.98, 1.51)	-	
Postpartum danger signs						
Not aware	-		-		Reference	
Aware	-		-		1.22	(1.02,1.46)
Nurse as information source						
Health information						
No	Reference		-		Reference	
Yes	2.08	(1.79,2.41)	-		0.94	(0.79, 1.13)
Delivery information						
No	-		Reference		-	
Yes	-		2.17	(1.82,2.58))	-	
Antenatal care use						
No prior use	Reference				-	
Prior use	1.87	(1.61,2.18)	-		-	
No use last pregnancy	-		Reference			
≥ visits last pregnancy	-		2.06	(1.73,2.44)		
Delivery care use						
No prior use	-		Reference		-	
Prior use	-		9.56	(7.67,11.92)	-	
No use last pregnancy	-		-		Reference	
Used for last pregnancy	-		-		15.35	(12.61,18.69)
Attitude towards delivery care						
Necessary for all	Reference		Reference		-	
Not necessary for all	0.51	(0.36, 0.71)	0.32	(0.22,0.47)	-	
Delivery mode ¹						
Not assisted	-		-		Reference	
Assisted	-		-		2.95	(1.95,4.45)
Household or inter-personal factors						
Wealthiest household group						
No	Reference		Reference		Reference	
Yes	1.52	(1.30,1.79)	1.36	(1.12, 1.66)	1.20	(0.99,1.46)
Companion support						
Not available	-		Reference		Reference	
Available	-		2.75	(2.20,3.43)	1.64	(1.28,2.08)
Health-related decisions						
Not involved	Reference		-		Reference	
Involved	1.33	(1.13,1.57)	-		1.10	(0.91, 1.34)

Potential explanatory factor	Antenatal care (n=3,687) ¹		Delivery care (n=3,681) ¹		Postnatal care (n=3,708) ¹	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
Delivery site decisions						
Not involved	-		Reference		-	
Involved	-		0.83 (0.67, 1.02)		-	
Parity	0.92	(0.89,0.95)	1.04	(0.99,1.08)	0.98	(0.94, 1.02)
Pregnancy planned						
No	Reference		-		-	
Yes	1.42	(1.21,1.66)	-		-	
Birth preparedness						
Did not plan	Reference				-	
Planned for delivery	1.46	(1.24,1.71)	1.45	(1.20,1.74)	-	
Health system factors						
Home visit by HEW						
No	Reference		Reference			
Yes	1.32	(1.13, 1.55)	1.35	(1.13,1.62)	1.14	(0.95, 1.36)
Nearby health facility type/level						
Not hospital/health centre	Reference		Reference		-	
Hospital/health centre	1.66	(1.44,1.92)	1.98	(1.67,2.36)	-	

¹ Denominators indicate number of women for whom data was available for all candidate explanatory variables. Differences between models are reflective of differences in data available (Nurse as health information source n=3,721; history of ANC use n=3,688; history of delivery care use n=3,682 and delivery mode n=3,714)

A dash (-) indicates that the variable was not included in the model either because it was removed to minimize local multicollinearity (ex: education for ANC model) or was not hypothesized to be a relevant explanatory factor (ex: delivery mode for ANC)

Comparison of results from the local GWR models and conventional global regression models revealed several things. Firstly, associations for some explanatory factors found to be statistically significant at the global level (Table 6.2) had widespread significant local associations as well, but differed in magnitude as illustrated by darker shades on maps. For instance, local estimates for ANC use and information source (Figure 6.2a) or prior ANC use (Figure 6.2c) were significant for households across most PHCUs in both Kersa and Seka Chekorsa districts as well as households in some Gomma districts *kebeles*. However, stronger associations between ANC use and information source could be seen in households in the northern PHCUs in Kersa district than those in the southern PHCUs (Figure 6.2a). Similarly, local associations of prior ANC use among households in PHCUs along the north-western parts of Kersa district were of higher magnitude than households in Seka Chekorsa district PHCUs (Figure 6.2c).

Statistically significant global associations, assumed to be relevant for the entire study area, were also found to have quite localized associations when local model results were considered for certain factors. Higher household wealth, for example, was most relevant for households in Kersa districts PHCUs and some households in *kebeles* in Geta Bake PHCU (Seka Chekorsa district) when it came to delivery care use (Figure 6.3h). In the other areas, such as households in Gomma district, other factors such as prior service use (Figure 6.3d or Figure 6.3e) and attitudes towards care (Figure 6.3f)

appeared to be more relevant. Contrastingly in Kersa, a relatively poorer district than Gomma, in addition to higher wealth levels, having companion support was associated with delivery care use in the northern parts (Figure 6.3g) but engaging in birth preparedness planning had significant associations with delivery care use in households in the southern *kebeles* (Figure 6.3j).

The localities for which explanatory factors exerted an influence also differed depending on the service considered. Having nurses as an information source exhibited significant associations with both ANC and delivery care use but the areas where these associations were detected differed; for ANC use strong associations could be seen in households from PHCUs in the south-central portion of the study area coinciding with Setemma, Wokito and Bake Gudo PHCUs (Figure 6.2a) while for delivery care no significant local estimates were detected for this factor in these areas (Figure 6.3b). Similarly, while having companion support appeared to be important for delivery care use among households in most PHCUs in Kersa and Seka Chekorsa districts (Figure 6.3g), it seemed to be relevant for fewer households concentrated mainly in *kebeles* from Geta Bake, Setemma and Kedemasa PHCUs for PNC use (Figure 6.4d).

Interestingly, women's involvement in decision making was found to be neither globally (Table 6.2) nor locally significant with respect to delivery care use and the test for spatial variability also did not find evidence of significant non-stationarity (results not shown). Finally, both global and local estimates for several explanatory factors for PNC use such as education, wealth, and parity were not statistically significant (local results not shown). However, spatial variability tests suggested that there was significant non-stationarity in relationships implying that the scale at which local associations were explored may be unsuitable (results not shown).

The Global Moran's I test conducted on GWR residuals was significant for all three services, indicating that there was still some spatial autocorrelation present.

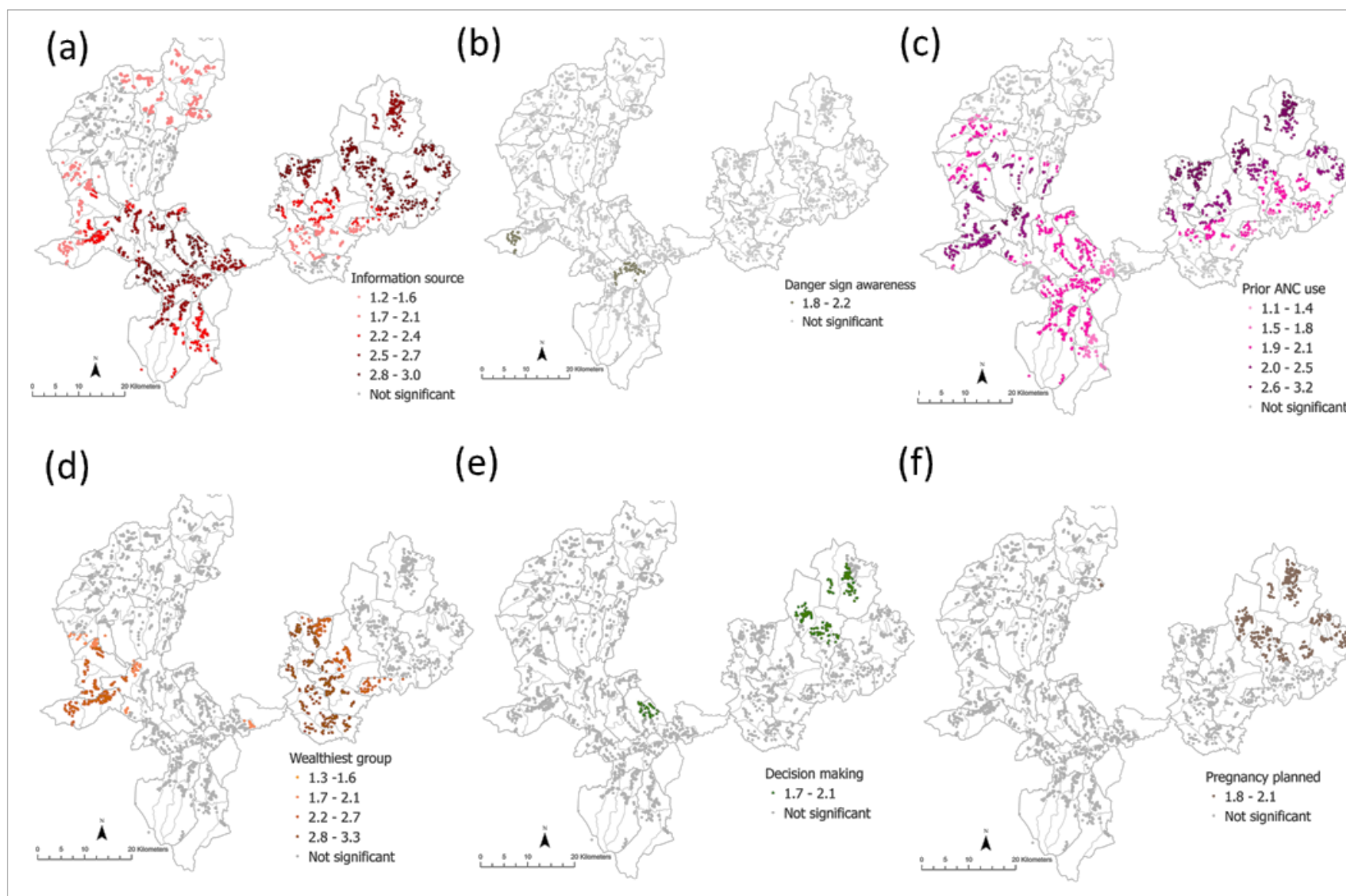


Figure 6.2. Maps of local association estimates (odds ratios) between ANC use and (a) information source (b) danger sign awareness (c) prior ANC use (d) wealthiest group (e) decision making (f) planned pregnancy

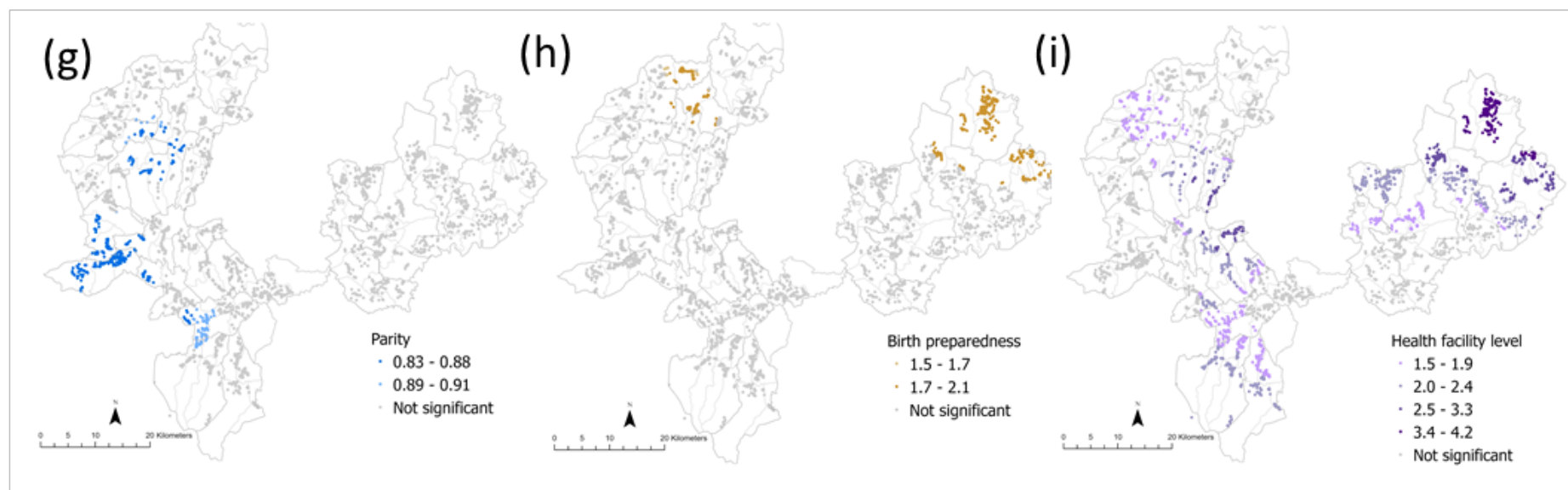


Figure 6.1 (continued). Maps of local association estimates (odds ratios) between ANC use and (g) parity (h) birth preparedness and (i) health facility type

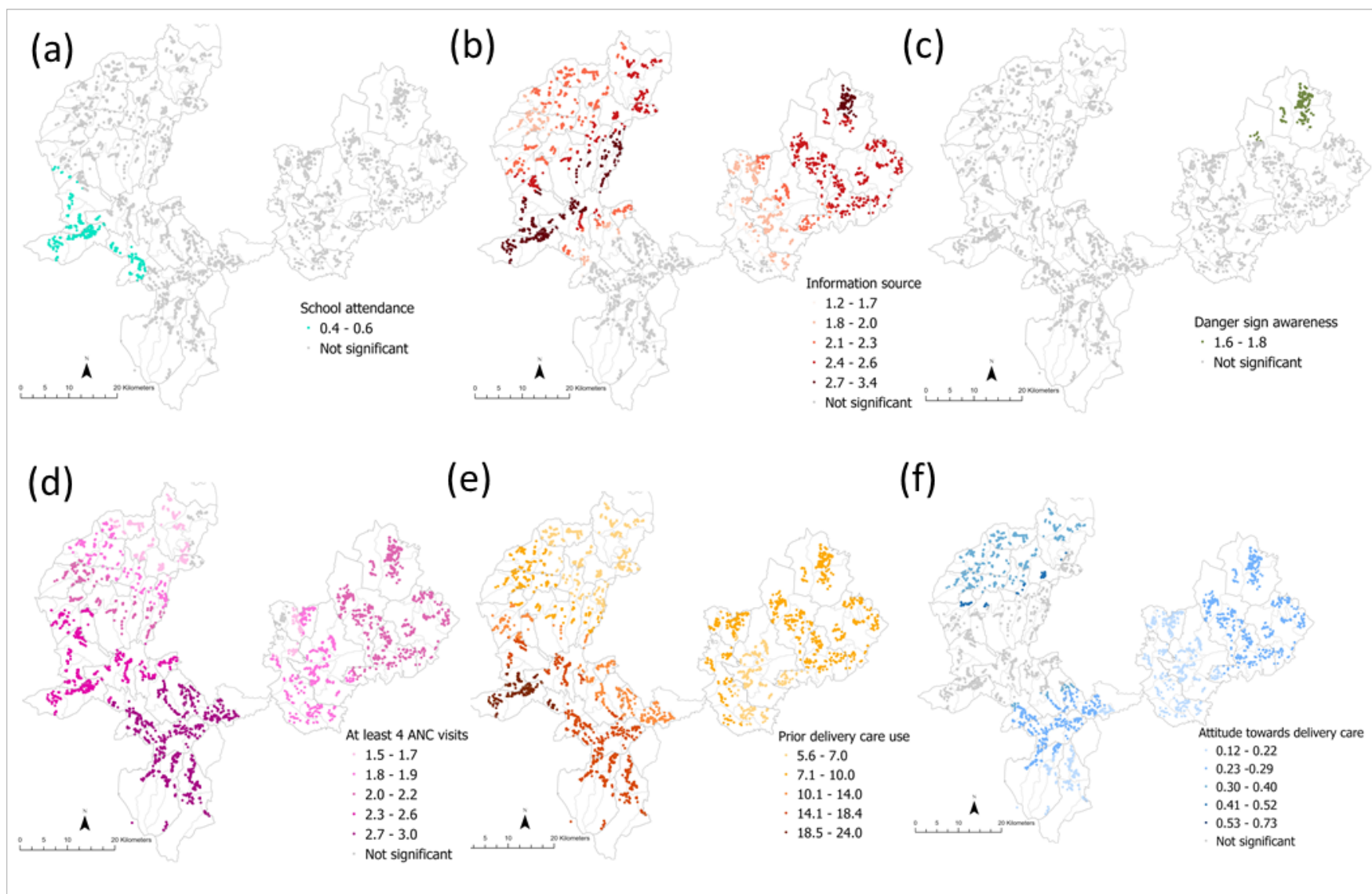


Figure 6.3
Maps of local
association
estimates
(odds ratios)
between
delivery care
and (a)
school
attendance
(b)
information
source (c)
danger sign
awareness (d)
ANC use (e)
prior delivery
care use (f)
attitude
towards
delivery care

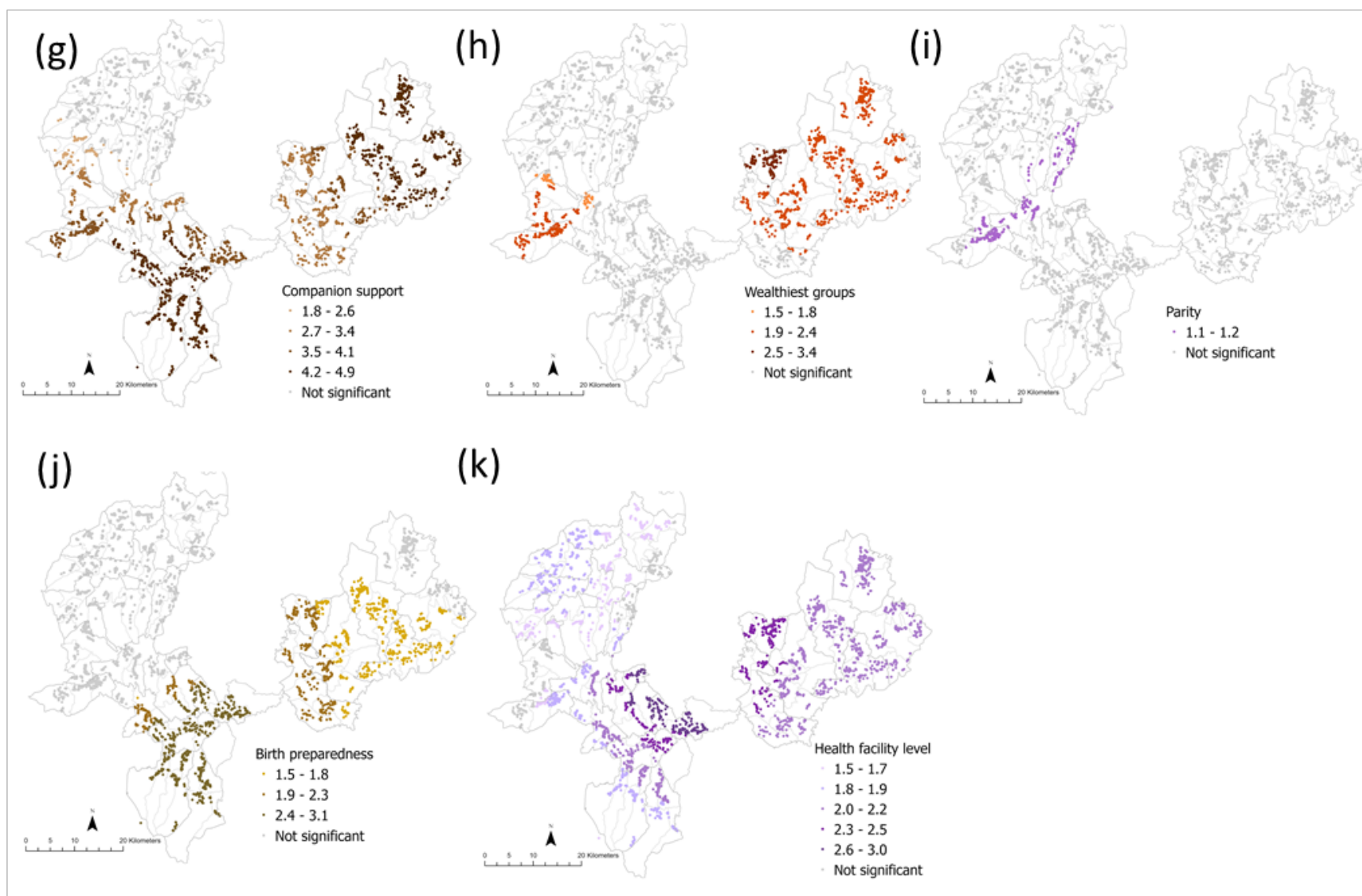


Figure 6.3
(continued)
Maps of
local
association
estimates
(odds ratios)
between
delivery care
and (g)
companion
support (h)
wealthiest
groups (i)
parity (j)
birth
preparedness
(k) health
facility level

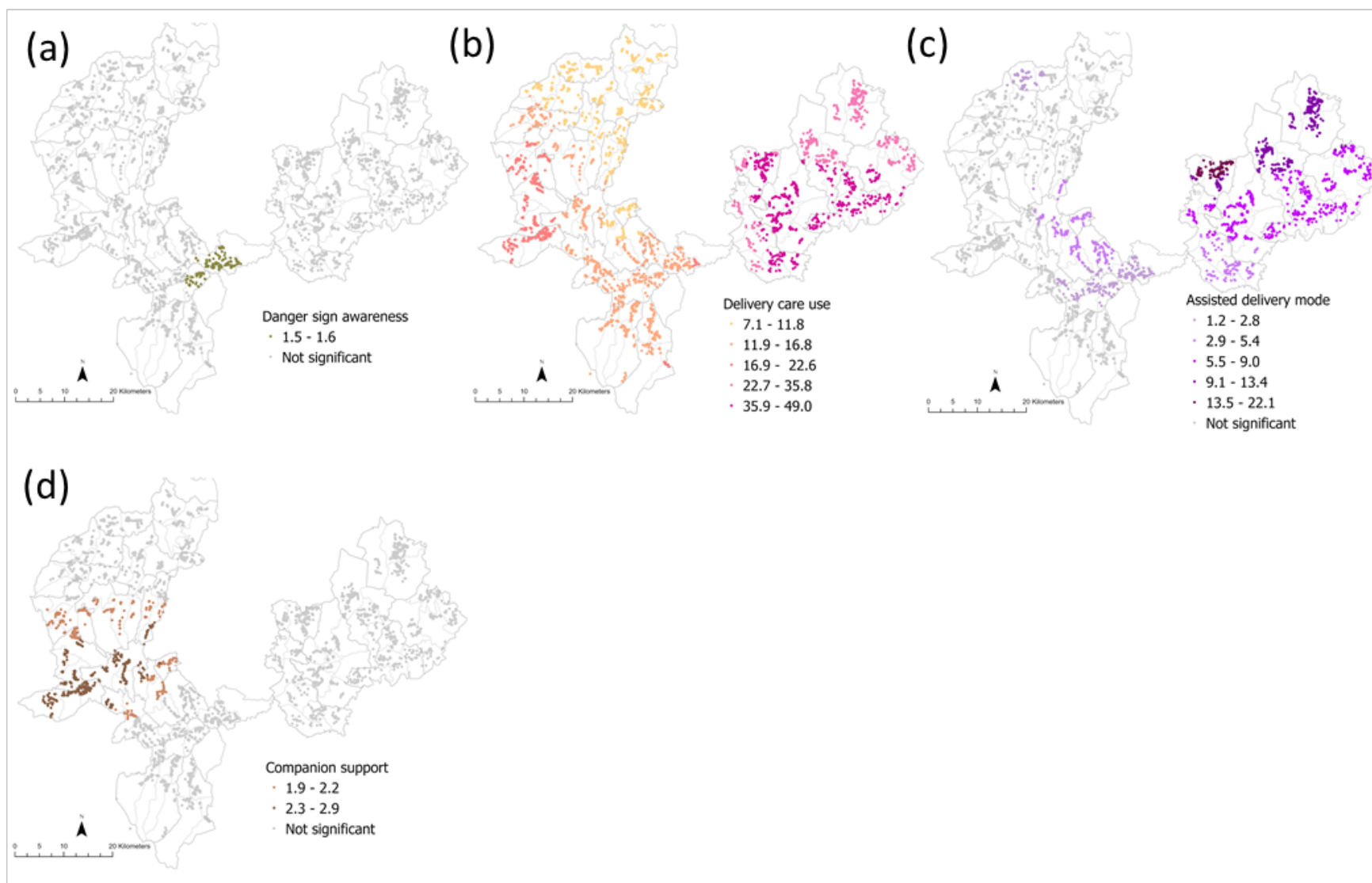


Figure 6.4
Maps of
local
association
estimates
(odds ratios)
between
PNC use
and (a)
danger sign
awareness
(b) delivery
care use (c)
Mode of
delivery (d)
companion
support

6.2.5. Discussion

Conventional regression models identified a series of individual, interpersonal and health system factors as important for maternal health service use. Several factors such as danger sign awareness (36,37), prior service use (38), wealth levels (39–41), parity (41–43) and whether or not a pregnancy was planned (36,39,44), have been reported by other studies investigating service use in Ethiopia. The use of GWR models, however, uncovered the existence of spatially varying associations between service use and explanatory factors suggesting that these variables may not be uniform in their influence on service use across the study area. Thus, GWRs potentially facilitate the exploration of place effects in ways traditional regression models cannot. Statistical regression models often “control” for place by including population composition variables (such as the proportion of educated women in a village) as proxies for local context. However, as Tunstall and colleagues explain this is unlikely to adequately capture the complex mechanisms that gave rise to these compositional differences to begin with.(45)

Understanding how geographical and social contexts shape what factors have prominence in affecting service use is essential for effective policy formulation and implementation. It is also a key component in the design of responsive health systems, which are described as being able to “anticipate and adapt to changing needs”.(46) Indeed strategies to create responsive health systems include gathering empirical evidence about the needs of the community to adapt services accordingly.(47) In localities where wealth drives service use, ensuring out-of-pocket expenses are minimized could be effective in encouraging use; whereas deploying more community health workers to promote better danger sign awareness may be more relevant in places where use is highly dependent on awareness of risks. Providing contextually-tailored care has also been identified as a fundamental dimension of equity-oriented primary health care services.(48) Once again, this underscores the need to have a clear understanding of local influences that shape use to prevent one-size-fits-all policies from perpetuating structural inequities that marginalize populations by ignoring place-specific effects.

Non-stationarity in service use associations may also partially explain conflicting findings from different studies about what seems to be driving maternal health service use. Women’s involvement in decisions about service use, for instance, has been described to be particularly important in patriarchal or hierarchical contexts where women are not primary decision makers.(49–52) However, while some studies find women’s decision-making involvement to be significantly associated with service use (53–55), others have not.(39,56) These studies originate from different districts and *kebeles* across Ethiopia and the results may partially be a consequence of this contextual diversity. In our study, we found involvement in health-related decision making to be a central factor affecting ANC use in very few *kebeles*. While these results do not downgrade the importance of women making their own decisions,

they do raise the possibility that other factors with statistically significant local estimates may be more influential in some of these areas.

6.2.6. Limitations

Characteristics of husbands, such as their education levels, were not included in the models due to concerns about selection bias and missing data. These factors may represent important explanatory variables missing from our model which could contribute to model misspecification and increase the likelihood of detecting spatial variation where none actually exists.(26) However, interpersonal and household variables, such as decision making, social support and household wealth, were included and likely capture some of the important dimensions of husband influence. There is also an under-representation of health system factors (such as quality of care) and geographic factors (like terrain) in our models. This reflects one of the limitations of GWR models where variables that do not have sufficient variability or that are common across large subsets of the data cannot be accommodated in the models.

A second limitation was related to the scale at which relationships between various explanatory factors and service outcomes were considered. Standard GWR models employ the use of a single bandwidth that is averaged across all independent variables in the model. This assumes that the relationships between each independent variable and the outcome operate at the same spatial scale.(57) Multiscale GWRs, which allow bandwidths to vary between explanatory variables, are currently not available for binary outcomes. However, bandwidth intervals can indicate the potential average spatial scales at which processes may be operating.(58) This may partially explain the spatial autocorrelation structure that was detected in the GWR residuals.

6.2.7. Conclusions

The presence of significant spatial variation in the relationships between service use and corresponding individual, interpersonal/household and health system factors highlights the importance of using analytic methods suited to capturing this variation adequately. GWR models facilitate the detection and exploration of this variability thus contributing to a more nuanced understanding of context-specific effects. The use of multiscale GWR models, that support the examination of relationship differences at several spatial scales could further enhance this understanding. Consideration of local variability in the relative importance of factors influencing service use is critical for the design of equity-oriented, responsive health systems and context-appropriate policy implementation.

6.2.8. List of abbreviations

AICc	Corrected Akaike Information Criterion
ANC	Antenatal care
CI	Confidence interval
GWR	Geographically weighted regression
HEW	Health extension worker
MWH	Maternity waiting home
PHCU	Primary health care unit
PNC	Postnatal care
VDP	Variance decomposition proportion
VIF	Variance inflation factor

6.2.9. Declarations

6.2.9.1. *Ethics approval and consent to participate*

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016).

6.2.9.2. *Consent for publication*

Not applicable

6.2.9.3. *Availability of data and material*

Data used for this analysis will be provided upon reasonable request to Dr. Manisha Kulkarni.

6.2.9.4. *Competing interests*

The authors declare that they have no competing interests.

6.2.9.5. *Funding*

This work was carried out with grants #108028-001 (Jimma University) and #108028-002 (University of Ottawa) from the Innovating for Maternal and Child Health in Africa initiative (co-funded by Global Affairs Canada (GAC), the Canadian Institutes of Health Research (CIHR) and Canada's International Development Research Centre (IDRC)); it does not necessarily reflect the opinions of these organizations. The funding agency had no role in design, data collection or analysis.

6.2.9.6. *Authors' contributions*

JK conceptualized and performed the analysis and wrote the first draft of the manuscript. MK and MT provided feedback on the overall analytic approach while ZL provide methodological guidance

for GWR modelling. CT provided support with use of GWR4 and acted as a helpful sounding board for analytic ideas. GB provided input on policy relevance to guide analytic decisions. All authors (JK, MK, CT, MT, GB, ZL) interpreted the findings, contributed to the development of the manuscript and approved the final manuscript.

6.2.10. Acknowledgements

We are grateful to the communities who have been generous with their time and thoughts and without whom this trial would not be possible. A special thanks to Professor A.S. Fotheringham for thoughtfully and quickly answering several questions related to analysis. We would also like to express gratitude to Dr. Benoit Talbot who helped to work on generating path distances for earlier spatial analyses planned that were ultimately not used. The authors would like to acknowledge the trial investigators from University of Ottawa (Dr. Ronald Labonté) and Jimma University (Lakew Abebe Gebretsadik, Dr. Sudhakar Morankar, Dr. Muluemebet Abera and Kunuz Bedru Haji) as well as the broader research team (Getachew Kiros, Abebe Mamo, Shifera Asfaw, Yisalemush Asefa, Gemechu Abene, Erko Endale, Nicole Bergen and Corinne Packer).

6.2.11. Article References

1. The Partnership for Maternal Newborn and Child Health. Opportunities for Africa's Newborns. Practical data, policy and programmatic support for newborns in Africa. Geneva, Switzerland; 2006.
2. Wang W, Alva S, Wang S, Fort A. Levels and trends in the use of maternal health services in developing countries. Calverton, Maryland; 2011.
3. World Health Organization. Maternal health. Global situation [Internet]. 2020 [cited 2020 Oct 22]. Available from: https://www.who.int/health-topics/maternal-health#tab=tab_2
4. World Health Organization. Maternal and newborn coverage [Internet]. 2020 [cited 2020 Oct 22]. Available from: <https://www.who.int/data/maternal-newborn-child-adolescent-ageing/maternal-and-newborn-data/maternal-and-newborn---coverage>
5. Requejo JH, Victora CG, Barros AJD, Berman P, Bhutta Z, Boerma T, et al. Countdown to 2015: a decade of tracking progress for maternal, newborn, and child survival. Geneva, Switzerland; 2015.
6. Central Statistical Authority. Ethiopia Demographic & Health Survey (2000). Addis Ababa & Calverton; 2001.
7. Ethiopian Public Health Institute. Mini Demographic & Health Survey (2019). Addis Ababa and Rockville, Maryland; 2019.
8. United Nations. SDG indicators. Global SDG Indicator Database [Internet]. 2020 [cited 2020 Oct 22]. Available from: <https://unstats.un.org/sdgs/indicators/database/>
9. Okedo-Alex IN, Akamike IC, Ezeanosike OB, Uneke CJ. Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. *BMJ Open*. 2019;9(e031890).
10. Guliani H, Sepehri A, Serieux J. Determinants of prenatal care use: Evidence from 32 low-income countries across Asia, Sub-Saharan Africa and Latin America. *Health Policy Plan*. 2014;29:589–602.

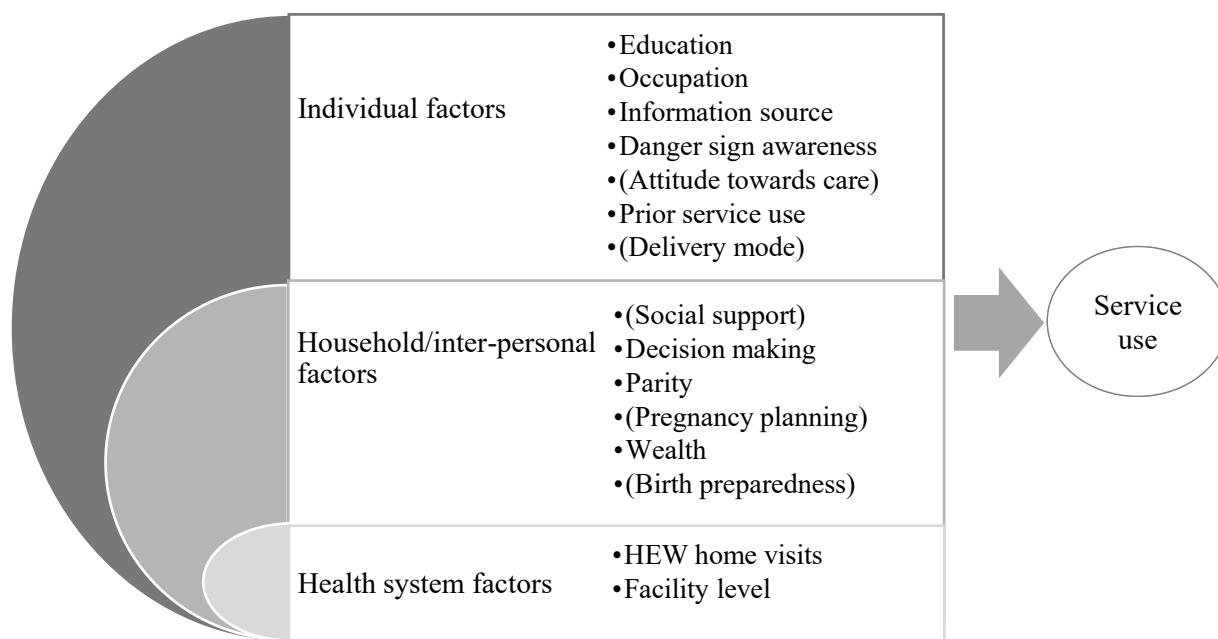
11. Diamond-Smith N, Sudhinaraset M. Drivers of facility deliveries in Africa and Asia: regional analyses using the demographic and health surveys. *Reprod Health*. 2015;12(6).
12. Langlois É V, Miskurka M, Victoria M, Ghaffar A, Ziegler D, Karp I. Inequities in postnatal care in low- and middle-income countries: a systematic review and meta-analysis. *Bull World Health Organ*. 2015;93:259–70.
13. Benova L, Owolabi O, Radovich E, Wong KLM, Macleod D, Langlois E V., et al. Provision of postpartum care to women giving birth in health facilities in sub-Saharan Africa: A cross-sectional study using Demographic and Health Survey data from 33 countries. *PLOS Med*. 2019;16(10):e1002943.
14. Chaka EE, Abdurahman AA, Nedjat S, Majdzadeh R. Utilization and Determinants of Postnatal Care Services in Ethiopia : A Systematic Review and Meta-Analysis. *Ethiop J Heal Sci*. 2019;29(1):935–44.
15. Fotheringham AS, Brunsdon C, Charlton M. Geographically weighted regression. Chichester: John Wiley & Sons Ltd; 2002.
16. Gangodagamage C, Zhou X, Lin H. Spatial autocorrelation. In: Shekhar S, Xiong H, editors. *GIS Encyclopedia*. 2nd ed. Geneva, Switzerland: Springer International; 2016. p. 32–7.
17. Kurji J, Talbot B, Bulcha G, Bedru KH, Morankar S, Gebretsadik LA, et al. Uncovering spatial variation in maternal healthcare service use at subnational level in Jimma Zone, Ethiopia. *BMC Health Serv Res*. 2020;20(703).
18. Moyer CA, Mustafa A. Drivers and deterrents of facility delivery in sub-Saharan Africa: a systematic review. *Reprod Health*. 2013;10(40).
19. Hill Z, Amare Y, Scheelbeek P, Schellenberg J. ‘People have started to deliver in the facility these days’: a qualitative exploration of factors affecting facility delivery in Ethiopia. *BMJ Open*. 2019;9(e025516).
20. Food and Agriculture Organization of the United Nations. Country profile - Ethiopia. Geneva; 2016.
21. Federal Democratic Republic of Ethiopia Ministry of Health. Health Sector Development Programme IV (2010/11 - 2014/15). Addis Ababa; 2010.
22. Oromia Bureau of Finance and Economic Development. Gomma district report. Jimma; 2016.
23. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2016.
24. Kurji J, Kulkarni MA, Gebretsadik LA, Wordofa MA, Morankar S, Bedru KH, et al. Effectiveness of Upgraded Maternity Waiting Homes and Local Leader Training in Improving Institutional Births among Women in Jimma Zone, Ethiopia: study protocol for a cluster randomized controlled trial. *Trials*. 2019;20(671).
25. Amouzou A, Hazel E, Sanni Y. Discordance in postnatal care between mothers and newborns : Measurement artifact or missed. *J Glob Health*. 2020;10(1).
26. Comber A, Brunsdon C, Charlton M, Dong G, Harris R, Lü Y, et al. The GWR route map: a guide to the informed application of Geographically Weighted Regression. 2020.
27. Pfeiffer DU, Robinson T, Stevenson M, Stevens KB, Rogers DJ, Clements ACA. *Spatial Analysis in Epidemiology*. Oxford: Oxford University Press; 2008.
28. Tobler WR. A Computer Movie Simulating Urban Growth in the Detroit Region. *Econ Geogr*. 1970;46(Supplement):234–40.
29. Oshan TM, Li Z, Kang W, Wolf LJ, Fotheringham SA. MGWR: A Python Implementation of

- Multiscale Geographically Weighted Regression for Investigating Process Spatial Heterogeneity and Scale. *Int J Geo-information*. 2019;6(269).
30. Wheeler D, Tiefelsdorf M. Multicollinearity and correlation among local regression coefficients in geographically weighted regression. *J Geogr Syst*. 2005;7:161–87.
 31. Fotheringham AS, Oshan TM. Geographically weighted regression and multicollinearity: dispelling the myth. *J Geogr Syst*. 2016;18:303–29.
 32. Kim JH. Multicollinearity and misleading statistical results. *Korean J Anesthesiol*. 2019;72(6):558–69.
 33. ESRI. How Geographically weighted regression works [Internet]. 2020 [cited 2020 Sep 16]. Available from: <https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/how-geographicallyweightedregression-works.htm>
 34. Wheeler DC. Diagnostic tools and a remedial method for collinearity in geographically weighted regression. *Environ Plan Ann*. 2007;39:2464–82.
 35. Da Silva RA, Fotheringham SA. The Multiple Testing Issue in Geographically Weighted Regression. *Geogr Anal*. 2016;48:233–47.
 36. Tewodros B, Gebremariam A, Dibaba Y. Factors affecting antenatal care utilization in Yem special woreda, southwestern Ethiopia. *Ethiop J Heal Sci*. 2009;19(1):45–50.
 37. Tadele N, Lamaro T. Utilization of institutional delivery service and associated factors in Bench Maji zone, Southwest Ethiopia: community based, cross sectional study. *BMC Health Serv Res*. 2017;17(101).
 38. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia : a multilevel analysis. *BMC Int Heal Hum Rights*. 2013;13(20).
 39. Dutamo Z, Assefa N, Egata G. Maternal health care use among married women in Hossaina, Ethiopia. *BMC Health Serv Res*. 2015;15(365).
 40. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes*. 2015;8(376).
 41. Mehari AM. Levels and Determinants of Use of Institutional Delivery Care Services among Women of Childbearing Age in Ethiopia: Analysis of EDHS 2000 and 2005 Data. DHS Working Papers. Calverton, Maryland; 2013.
 42. Yebyo HG, Gebreselassie MA, Kahsay AB. Individual and community-level predictors of home delivery in Ethiopia: A multilevel mixed-effects analysis of the 2011 Ethiopia National Demographic and Health Survey. DHS Working Papers No. 104. 2014.
 43. Mezmur M, Navaneetham K, Letamo G, Bariagaber H. Individual, household and contextual factors associated with skilled delivery care in Ethiopia: Evidence from Ethiopian demographic and health surveys. *PLoS One*. 2017;12(9).
 44. Arba MA, Darebo TD, Koyira MM. Institutional Delivery Service Utilization among Women from Rural Districts of Wolaita and Dawro Zones , Southern Ethiopia ; a Community Based Cross-Sectional Study. *PLoS One*. 2016;11(3):e0151082.
 45. Tunstall HVZ, Shaw M, Dorling D. Places and health. *J Epidemiol Community Heal*. 2004;58:6–10.
 46. Mirzoev T, Kane S. What is health systems responsiveness? Review of existing knowledge and proposed conceptual framework. *BMJ Glob Heal*. 2017;2:e000486.

47. Seeleman C, Essink-Bot M-L, Stronks K, Ingleby D. How should health service organizations respond to diversity? A content analysis of six approaches. *BMC Health Serv Res.* 2015;15(510).
48. Browne AJ, Varcoe CM, Wong ST, Smye VL, Lavoie J, Littlejohn D, et al. Closing the health equity gap: evidence-based strategies for primary health care organizations. *Int J Equity Health.* 2012;11(59).
49. Gabrysch S, Campbell OMR. Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy Childbirth.* 2009;9(34).
50. Kea AZ, Tulloch O, Datiko DG, Theobald S, Kok MC. Exploring barriers to the use of formal maternal health services and priority areas for action in Sidama zone, southern Ethiopia. *BMC Pregnancy Childbirth.* 2018;18(96).
51. King R, Jackson R, Dietsch E, Hailemariam A. Barriers and facilitators to accessing skilled birth attendants in Afar region, Ethiopia. *Midwifery.* 2015;31:540–6.
52. Finlayson K, Downe S. Why Do Women Not Use Antenatal Services in Low- and Middle-Income Countries? A Meta-Synthesis of Qualitative Studies. *PLoS Med.* 2013;10(1):e1001373.
53. Fikre AA, Demissie M. Prevalence of institutional delivery and associated factors in Dodota Woreda (district), Oromia regional state, Ethiopia. *Reprod Health.* 2012;9(33).
54. Hailu D, Berhe H. Determinants of institutional childbirth service utilisation among women of childbearing age in urban and rural areas of Tsegedie district, Ethiopia. *Midwifery.* 2014;30:1109–17.
55. Dida N, Birhanu Z, Gerbaba M, Tilahun D, Morankar S. Modeling the probability of giving birth at health institutions among pregnant women attending antenatal care in West Shewa Zone, Oromia, Ethiopia: A cross sectional study. *Afr Health Sci.* 2014;14(2):288–98.
56. Tiruneh FN, Chuang K, Chuang Y. Women's autonomy and maternal healthcare service utilization in Ethiopia. *BMC Health Serv Res.* 2017;17(718).
57. Fotheringham AS, Yang W, Kang W. Multiscale Geographically Weighted Regression (MGWR). *Ann Am Assoc Geogr.* 2017;107(6):1247–65.
58. Li Z, Fotheringham AS, Oshan TM, Wolf LJ. Measuring Bandwidth Uncertainty in Multiscale Geographically Weighted Regression Using Akaike Weights. *Ann Am Assoc Geogr.* 2020;110(5):1500–20.

6.3. Article supplementary material

6.3.1. Supplement 1: Conceptual model



Supplement figure 1. Conceptual model of factors hypothesized to be associated with maternal healthcare service use. Brackets indicate factors relevant for specific services.

6.3.2. Supplement 2: Definitions of candidate explanatory variables used in the global and local models

Variable	Description
Individual factors	
Education	A binary variable created from women's responses about whether or not they had received any formal education at any level (primary, secondary or higher).
Information source	Two binary variables were created from multiple response variables indicating women's sources of information about (i) health or (ii) birth. Sources included nurses, HEWs, husbands, relatives, friends and others. Responses were classified into whether or not nurses (the most reliable source available) were listed as an information source. The nurses as sources for health-related information variable was used for the ANC and PNC models, while the nurses as sources of birth-related information source was used for the delivery care model
Danger sign awareness	Women were asked to list symptoms of serious health problems that can occur during pregnancy, birth or during the postpartum period. Binary variables (yes/no) were created to indicate whether or not women could name at least one danger sign (such as vaginal bleeding, severe headaches, blurred vision, convulsions, swollen face or hands, high fever, etc) during: (i) pregnancy (used for ANC model), (ii) birth (used for delivery care model) and, (iii) after birth (used for the PNC model)
Attitude towards care	A binary variable created from responses when women were asked if they agreed or disagreed with the statement that women with prior experience giving birth to a child did not need to deliver subsequent children at a health facility. Used for delivery care model.
Prior service use	Two binary variables were created indicating whether or not women reported: (i) ever using ANC services during past pregnancies (used for ANC model) and, (ii) ever delivering previous children at a health facility (used for delivery care model)
Delivery mode	This variable was hypothesized to be relevant only for PNC use. A binary variable was created to indicate whether or not the woman reported having an assisted delivery (caesarean section, vacuum or forceps extraction) during the birth of her last child.
Interpersonal or household factors	
Social support	Women were asked about several dimensions of social support. The dimension hypothesized to be most relevant for accessing services was having a companion to accompany women to the health facility. Women who indicated they had a companion available during pregnancy, labour and after delivery were classified as "Yes". Considered to be an inter-personal/household factor as women draw social support from various members of their social networks including husbands, family members, neighbours, friends, etc

Variable	Description
Involvement in decision making	Women were asked who was involved in decisions around the place of delivery and health-related decisions. Responses indicating their participation in the decision-making process (i.e., decision-maker included “self” or “jointly with husband”) were classified as “Involved” while all other responses (husband only, family member only) were classified as “Not involved”. The variable indicating involvement in health-related decisions was used for ANC and PNC models, while decision making around place of delivery was used for deliver care models.
Pregnancy planned	Women were asked if they had planned their last pregnancies. A binary variable (yes/no) was created from their responses.
Parity	A count variable indicating the total number of times women reporting having given birth to a child. Considered to be an inter-personal/household factor as the number of children a woman has is also influenced by her husband.
Wealth	An asset-based wealth index was created using principal components analysis on asset ownership (radio, television, mobile phone, motorbike, car/truck, livestock), presence of utilities (electricity and drinking water source), sanitation facilities, health insurance and dwelling construction materials. Scores were ranked and divided into quintiles. A binary variable was created for this analysis to indicate whether or not women belonged to the least poor households (quintiles four and five).
Birth preparedness	Women were asked if they did anything to prepare for the birth of their last child prior to delivery. Responses included items as such saving money, identifying means of transport or getting a referral for maternity waiting home use and were classified as “Yes”. Considered to be an inter-personal/household factor as certain planning dimensions such as organizing transport require input from husbands
Health system factors	
Home visit	A binary variable indicating whether or not a community-based health extension worker visited the woman’s home during the antenatal and postpartum period of her last child. Considered a health-system factor as HEWs represent the community-based segment of the health system structure.
Health facility type	A binary variable indicating whether or not women reported having a hospital or health centre near their home.

Chapter 7: Do MWHs⁺ and trained local leaders increase use of maternal healthcare services?

7.1. Article preface

In the final article in my thesis, I present the results of the trial which had a primary objective of evaluating the effectiveness of the two intervention components, MWH⁺ and local leader training, in improving institutional births. A secondary objective was to determine if these interventions had an effect on antenatal care (ANC) and postnatal care (PNC) service use in a rural Ethiopian setting.

7.1.1. Author contributions:

The Safe Motherhood project was conceptualized by the co-principal investigators Mr. Lakew Gebretsadik and Dr. Sudhakar Morankar (Jimma University) and, Dr. Ronald Labonté and Dr. Manisha Kulkarni (Ottawa University) with input from Dr. Muluemebet Wordofa (Jimma University), Mr. Kunuz Bedru and Mr. Gebeyehu Bulcha (Jimma Zone Health Office). Dr. Kulkarni led the overall trial design with input from Dr. Monica Taljaard. Under the guidance of Dr. Taljaard, I formulated the trial analysis plan. I created the household survey tools based on some initial work by Dr. Wordofa. The tools were finalized with input from Drs. Kulkarni and Morankar and Mr. Gebretsadik. The social support question module was created by Mr. Abebe Mamo, a PhD student from Jimma University. I was part of the working group that designed the MWH intervention component. I conducted all the trial analyses under guidance from Drs. Taljaard and Kulkarni. I wrote up the first draft of the manuscript. All authors contributed to the interpretation of the results and provided feedback on my responses to the reviewers during the peer review process.

7.1.2. Associated appendices

Details about the ancillary analyses associated with the trial are detailed in Appendix 7.1.

7.1.3. Ethical approvals

Ethics approval for the overall study was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Ethics approval for my doctoral research was obtained from the University of Ottawa Health Sciences and Science REB (File No: H02-18-02).

7.1.4. Article citation

Kurji J, Gebretsadik LA, Wordofa MA, et al. Effectiveness of upgraded maternity waiting homes and local leader training on improving institutional births: a cluster-randomized controlled trial in Jimma, Ethiopia. *BMC Public Health*. 2020 Oct 22;20(1):1593. doi: 10.1186/s12889-020-09692-4.

7.2. **Article content**

Article title: Effectiveness of upgraded maternity waiting homes and local leader training on improving institutional births: a cluster-randomized controlled trial in Jimma, Ethiopia

Authors:

Jaameeta Kurji
School of Epidemiology and Public Health, University of Ottawa

Lakew Abebe Gebretsadik
Department of Health, Behaviour & Society, Jimma University

Muluemebet Abera Wordofa
Department of Population & Family Health, Jimma University

Sudhakar Morankar
Department of Health, Behaviour & Society, Jimma University

Kunuz Haji Bedru
Jimma Zone Health Office

Gebeyehu Bulcha
Jimma Zone Health Office

Nicole Bergen
Faculty of Health Sciences, University of Ottawa

Getachew Kiros
Department of Health, Behaviour & Society, Jimma University

Yisalemush Asefa
Department of Health Economics, Management & Policy, Jimma University

Shifera Asfaw
Department of Health, Behaviour & Society, Jimma University

Abebe Mamo
Department of Health, Behaviour & Society, Jimma University

Erko Endale
Department of Health, Behaviour & Society, Jimma University

Kednapa Thavorn
Ottawa Hospital Research Institute, Ottawa Hospital, General Campus

Ronald Labonté
School of Epidemiology and Public Health, University of Ottawa

Monica Taljaard
Ottawa Hospital Research Institute, Ottawa Hospital, Civic Campus

Manisha A. Kulkarni
School of Epidemiology and Public Health, University of Ottawa

7.2.1. Abstract

Background: Maternity waiting homes (MWHs), residential spaces for pregnant women close to obstetric care facilities, are being used to tackle physical barriers to access. However, their effectiveness has not been rigorously assessed. The objective of this cluster randomized trial was to evaluate the effectiveness of functional MWHs combined with community mobilization by trained local leaders in improving institutional births in Jimma Zone, Ethiopia.

Methods: A pragmatic, parallel arm cluster-randomized trial was conducted in three districts. Twenty-four primary health care units (PHCUs) were randomly assigned to either (i) upgraded MWH^s combined with local leader training on safe motherhood strategies, (ii) local leader training only, or (iii) usual care. Data were collected using repeat cross-sectional surveys at baseline and 21 months after intervention delivery to assess the effect of interventions on the primary outcome, defined as institutional births, at the individual level. Women who had a pregnancy outcome (livebirth, stillbirth or abortion) 12 months prior to being surveyed were eligible for interview. Random effects logistic regression was used to evaluate the effect of the interventions.

Results: Data from 24 PHCUs and 7,593 women were analysed using intention-to-treat. The proportion of institutional births was comparable at baseline between the three arms. At endline, institutional births were slightly higher in the MWH⁺ & training (54% [n=671/1,239]) and training only arms (65% [n=821/1,263]) compared to usual care (51% [n=646/1,271]). MWH use at baseline was 6.7% (n=256/3,784) and 5.8% at endline (n=219/3,809). Both intervention groups exhibited a non-statistically significant higher odds of institutional births compared to usual care (MWH⁺ & training odds ratio [OR]=1.09, 97.5% confidence interval [CI] 0.67 to 1.75; leader training OR=1.37, 97.5% CI 0.85 to 2.22).

Conclusions: Both the combined MWH⁺ & leader training and the leader training alone intervention led to a small but non-significant increase in institutional births when compared to usual care. Implementation challenges and short intervention duration may have hindered intervention

effectiveness. Nevertheless, the observed increases suggest the interventions have potential to improve women's use of maternal healthcare services. Optimal distances at which MWHs are most beneficial to women need to be investigated.

Trial registration: The trial was retrospectively registered on the Clinical Trials website (<https://clinicaltrials.gov>) on 3rd October 2017. The trial identifier is NCT03299491.

7.2.2. Background

Maternity waiting homes (MWHs), which are temporary residential facilities within or close to health facilities, have been used to improve pregnant women's access to skilled obstetric care for almost seven decades (1) in an effort to stem maternal mortality rates. MWHs may be of particular interest in Sub-Saharan Africa where the level of maternal mortality was still highest in the world in 2017 (542 maternal deaths per 100,000 livebirths).(2)

In 2016, institutional births in Ethiopia stood at just 26% with substantial variation occurring between regions.(3) Several barriers to accessing maternal healthcare services are experienced by women (4,5); chief among them are geographical (6–10) and social factors (5,11–13). MWHs typically target women experiencing geographical barriers to accessing obstetric care and those with a high risk of delivery complications.

In 2011, there were nine MWHs in Ethiopia located in faith-based or non-governmental organization health facilities (14); by 2016, over half of the national facilities surveyed were providing waiting services.(15) Despite the integration of MWHs as part of national efforts to improve maternal and child health (16), their effectiveness has not been evaluated in a trial setting.(17) Observational studies from Zimbabwe comparing MWH users to non-users have reported favourable pregnancy (18) and neonatal (19,20) outcomes among MWH users. In Ethiopia specifically, a retrospective, hospital-based cohort study using 2011-2014 data reported lower odds of stillbirths (OR=0.18, 95% CI: 0.13 to 0.25) and a lower number of maternal deaths (0% vs. 0.3%) among MWH users compared to non-users.(21)

Levels of MWH utilization globally have been reported to be sub-optimal, partly due to the poor quality of services available at MWHs.(17) A recent Zambian study using upgraded MWHs reported increased utilization levels at one of the two improved sites.(22) Social support for pregnant women has also been found to impact MWH use.(23) Women often require family and neighbours to

assist with childcare (24–26) and household chores while they are away; in instances where food is not provided, MWH users require family assistance in supplying meals. Women's absence may also result in loss of family income requiring support from their husbands.(14,27) Community support is particularly important in the Ethiopian context where MWHs rely on community contributions for their construction and operation (16) and could influence use.(27)

In light of the evidence gap concerning the effectiveness of MWHs to improve institutional birth levels, two intervention components were developed: upgraded MWHs to provide quality services (MWH⁺), and training for local religious and community leaders to create an enabling environment for women and their families to access MWHs and obstetric care. The objective of the trial was to evaluate the effectiveness of upgraded MWHs and local leader training in improving institutional births in Jimma Zone, Ethiopia.

7.2.3. Methods

The trial protocol has been published previously (28) and the trial was retrospectively registered on 3rd October 2017 with Clinical Trials (trial identifier: NCT0329949).

7.2.3.1. *Setting*

The trial was conducted within Gomma, Seka Chekorsa and Kersa districts in Jimma Zone, Oromia region (Figure 7.1). Together, the districts had about 153,000 households in 2015/2016.(29) Jimma town, situated roughly in the centre of the three districts, is about 350 kilometres from the capital, Addis Ababa.

Women typically receive maternal healthcare services at primary health care unit (PHCU) level; PHCUs comprise a health centre and satellite health posts that are each operated by community-based health extension workers (HEWs). Health posts serve populations of up to 5000 by providing preventive and basic curative services. Jimma Zone has eight hospitals, 122 health centres and 566 health posts.(30) HEWs function as important links between the community and the health system by referring women to health centres for antenatal and obstetric care and providing follow up postnatal care (PNC). They

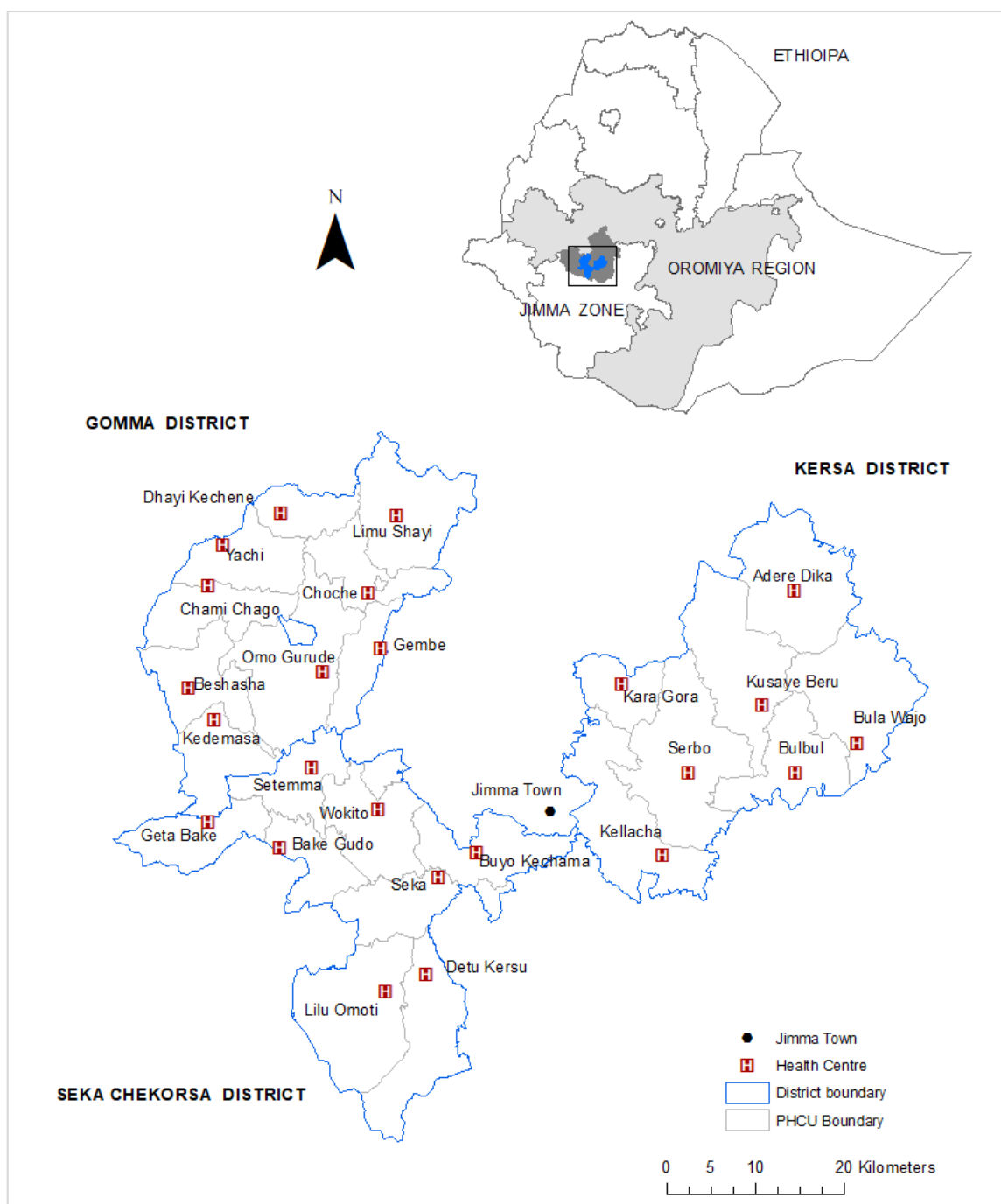


Figure 7.1. Map of study districts depicting locations of health centres and Jimma Town (created using ArcMap version 10.6.1 Redlands, CA: Environmental Systems Research Institute, Inc.)

are often supported by the Women's Development Army (WDA) whose members are women regarded as leaders in their communities for successfully adopting the health and sanitation guidelines outlined in the Health Extension Program packages.(31) Health centres are usually staffed with clinical officers and midwives; in 2016, 21 of the 24 study health centres had one or two midwives trained in basic emergency obstetric care (BEmOC).(29)

7.2.3.2. Design

A pragmatic, three-arm, stratified, cluster-randomized trial design was used to evaluate the effect of upgraded, functional MWHs (MWH⁺) and leader training on the primary outcome of institutional births. The trial arms consisted of: (i) upgraded MWH⁺ combined with religious and community leader training (“local leader training”) around safe motherhood strategies to mobilize communities; (ii) local leader training alone; and, (iii) usual care. PHCU catchment areas served as clusters, were randomized to trial arms, and were the level at which the interventions were delivered.

PHCUs were eligible to participate in the trial if maternity waiting services were available at the health centre. Women of reproductive age who reported a pregnancy outcome (livebirth, stillbirth, induced or spontaneous abortion) within the 12 months prior to each round of survey were eligible for inclusion in cross-sectional surveys at baseline and 21 months post intervention roll-out.(28) Women who experienced induced/spontaneous abortions were not excluded as they could still benefit from the leader training intervention activities and seek maternal healthcare services. In order to detect an absolute difference in the proportion of institutional births of 0.17 with 80% power, 24 clusters with 160 women each (assuming equal cluster sizes) were required for each round of surveys. This assumed a control arm proportion of 0.4 and used a two-sided alpha of 0.025 to account for two pairwise comparisons.(28) Using the method described by Hooper and Bourke, the product of two design effects were used to inflate the sample size required under a similarly powered individually randomized design. The first design effect, due to cluster randomization, was calculated using a within-period intracluster correlation coefficient (ICC) of 0.1 (32); the second design effect, due to repeated assessments, was calculated using the within-period ICC and a cluster autocorrelation coefficient of 0.8 which allowed for a 20% decay in strength of the ICC among women surveyed in different time periods.(33)

To ensure a balanced distribution of poorly functioning MWHs and health centres with low capacity to provide BEmOC, stratified randomization was used as described previously.(28) Briefly, using 2016 Jimma Zone Health Office (JZHO) data on MWH functionality, MWHs were classified as high functioning (≥ 5 service indicators present) or low functioning (<5 service indicators present). BEmOC capacity was classed as high (≥ 5 of the 7 signal functions present) or low (<5 signal functions present). Clusters were grouped into the four strata that resulted and a random number generator in STATA version 15 (College Station, STATA Corp) was used to create the allocation sequence. The allocation sequence was made known to the study coordinator in May 2017 when distribution of MWH supplies to intervention sites began; this was also when health centre staff at MWH⁺ & leader training sites were made aware of their allocation status.

Data collectors identified randomly pre-selected households, screened women for eligibility, provided information (survey objectives, institutions involved, expectations from participants, participant rights, and risks and benefits of participating), answered questions and took verbal consent from women wishing to be interviewed. About 4% of women interviewed at endline were also interviewed during baseline as no exclusions were made based on prior participation.

7.2.3.3. *Usual care*

The level of existing services is described in the trial protocol.(28) Briefly, MWHs are modelled as government-community partnerships and rely on cash or in-kind contributions from the community for construction and operation. There was considerable variation in quality across the MWHs in the study area. In 2016, 16 of the 24 waiting facilities were poorly functioning lacking basic items such as bedding, cooking utensils, a reliable water supply or electricity.(29) Women generally depend on HEW or midwives referrals to access MWHs and referral practices differed between sites.

HEWs are mostly responsible for conducting health promotion activities within the community and are aided by the WDA. Religious leaders are acknowledged to be influential members of the community and formative work revealed that they consider promoting access to maternal healthcare services and providing support to pregnant women part of their role.(34) However, there is little evidence of how widespread or consistent efforts by religious leaders are to promote institutional births and/or use of MWHs in the study districts.

7.2.3.4. *Interventions*

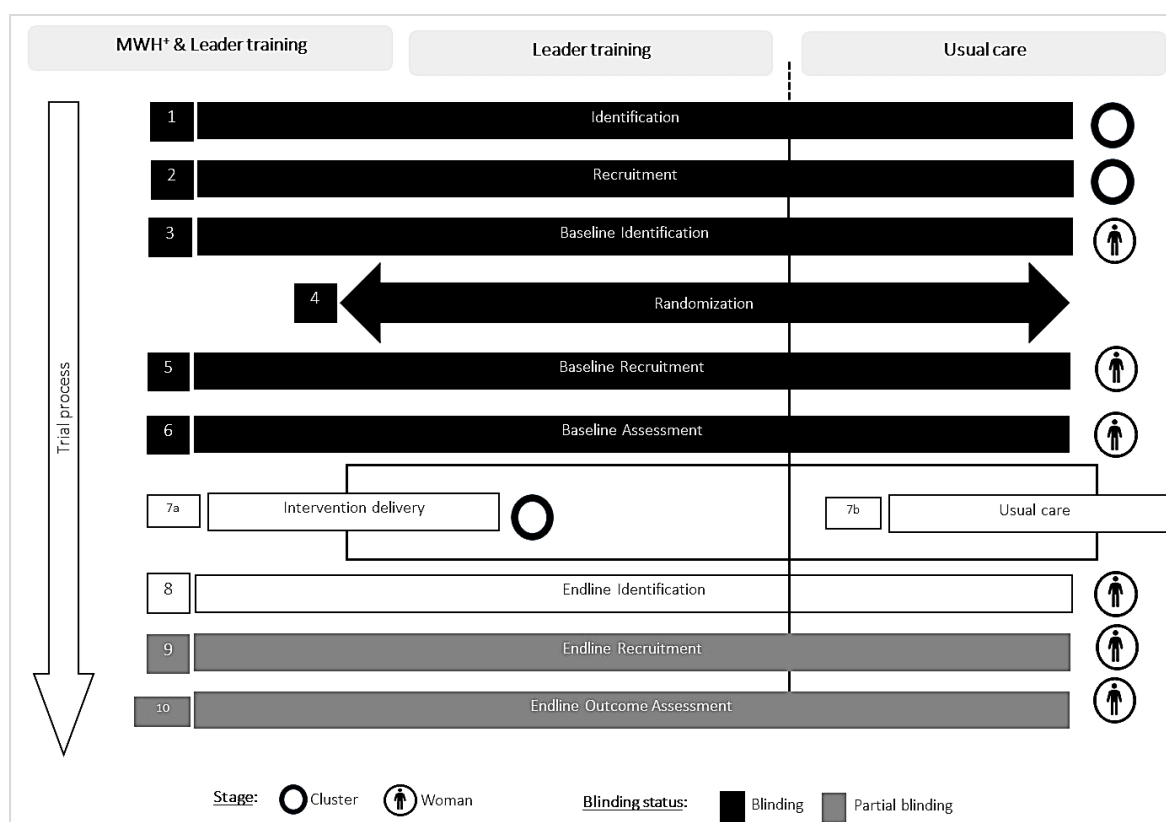
The MWH⁺ intervention component entailed upgrading and standardizing existing waiting facilities based on minimum needs identified through formative evaluation (28) and guided by the national policy (16) to create a home-like environment for pregnant users. MWHs situated at health centres in intervention arms were equipped with bedding, utensils and personal hygiene items, solar lamps, water tanks, drinking water purifiers, cooking stoves and cleaning items. Supplies were transported to intervention sites under the auspices of the district health offices. Remuneration for an MWH attendant to cook and clean was also provided. A register was also introduced to better track users.(28) In order to avoid disrupting the community contribution systems used to support MWHs, particularly with food provision, no meals were supplied through the study. During the first month after supply distribution, the study coordinator visited intervention sites to ensure appropriate setup of materials at the MWH⁺s and to brief midwives on correct completion of the MWH register placed at interventions MWHs. However, after this time supportive supervision visits were part of the agreed-

upon role of the JZHO and the District Health Offices. This strategy was employed to test out and facilitate sustainable mechanisms of MWH⁺ operation.

In recognition of the fact that women's social environments are as important in influencing use of maternal healthcare services (35,36) as individual-level factors, such as education (37,38), and service quality, the local leader training intervention component was created. HEWs, religious leaders and community leaders (such as members of the WDA) attended workshops that facilitated identification of access barriers to maternal healthcare services. HEWs were all women with at least a secondary school education and were between 20-30 years of age. WDA members generally reflected the demographic profile of women in the community. Religious leaders from the two major religious groups in the area (Christian and Muslim) were mostly male, had completed some level of primary school and were between 30 and 50 years of age. Building on their experiences, participants were encouraged to identify strategies to support their communities in overcoming these barriers to make motherhood safer and to promote use of antenatal care, MWHs, delivery care at facilities and postnatal care. Due to the pragmatic nature of the trial, the commitment to community empowerment and establishment of sustainable practices, leaders were encouraged to create activities they felt were optimal for their communities. Positive strategies used to improve access to services identified through formative research (such as urging women's social networks to assist with childcare and domestic chores, encouraging family and friends to accompany pregnant women to health facilities or working together to organize transport for women) (34) were discussed during training as part of brainstorming locally suited strategies for leaders to promote. HEWs committed to co-facilitating the WDA workshops, revamping pregnant women conferences to discuss safe motherhood and use of MWHs with women and collaborating with religious leaders to improve community contributions to MWHs. Religious leaders opted to address safe motherhood strategies during their religious gatherings and attend any community events organized by HEWs and WDAs to promote use of maternal healthcare services or tackle access challenges faced by the community.

7.2.3.5. *Blinding*

Data collectors were blind to women's allocation status during both baseline and endline assessments. It was not possible to blind women or intervention providers to intervention status but both groups were unaware of the study hypotheses. Figure 7.2 outlines the trial processes depicting order of participant recruitment, randomization, intervention delivery and outcome assessments; blinding status is indicated using black for complete blinding and grey for partial blinding. This timeline cluster tool is recommended for assessing risk of bias in cluster randomised trials.(39)



- 1 **Cluster identification:** Eligible clusters (primary health care units (PHCUs) with MWH services offered at the health centre) were identified by Jimma Zone Health Office (JZHO) from their records of all PHCUs in the districts in Jimma Zone. The three study districts were selected because of their large population size, availability of MWH services and absence of active maternal and child health interventions at the time.
- 2 **Cluster recruitment:** JZHO and research team members from Jimma University discussed the trial with district level administration and PHCU directors and obtained approval for cluster participation. Stakeholders were informed of the 24 randomly selected sites in March 2016.
- 3 **Baseline participant identification:** A listing exercise was carried out (May-August 2016) to update and verify the lists of pregnant women maintained by health extension workers (HEWs) at health posts as part of routine community monitoring. These lists were used as the sampling frame from which eligible women were randomly selected using a computer-based random number generator by MAK and JK not involved in data collection or field activities.
- 4 **Randomization:** MAK stratified clusters based on MWH functionality and emergency obstetric care capacity and then randomized them to one of three trial arms in September 2016. The allocation status was shared with LAG, the local principal investigator only. Neither LAG nor MAK was not involved with participant or cluster recruitment, intervention delivery or outcome assessments during the trial.
- 5 **Baseline participant recruitment:** Lists of randomly selected women were shared with field supervisors prior to baseline survey commencement in October 2016. Data collectors identified selected households with the help of village guides and screened women for eligibility and obtained consent.
- 6 **Participant baseline assessment:** Data collectors administered questionnaires on tablet computers to enrolled women. Baseline data collection was completed in January 2017.
- 7a **Intervention delivery:** Communication of the allocation status of the study sites (to study coordinator involved in managing the logistics of transporting supplies to upgraded MWH sites as well as trainers responsible for HEW and workshops) occurred in May 2017 prior to commencement of supply distribution. Supply distribution was completed at the end of May 2017. From this point, providers (HEWs, midwives, leaders) were likely aware of allocation status. Women who used health centre services were also likely aware of their PHCUs allocation status. Training of HEWs and religious leaders started in May 2017. After training, intervention activities ranged from health education sessions at mosques/churches conducted by religious leaders to promotion of MWH use at pregnant women conferences by HEWs. Training of community leaders began later than scheduled in October 2017 and took a month to complete. Activities conducted by the Women's Development Army (community leaders) included helping HEWs to refer women to MWHs, accompanying women to MWHs, mobilizing community contributions towards MWHs, organizing traditional ambulances for labouring women).
- 7b **Usual care:** Women receive usual services at unimproved MWHs and routine engagement by HEWs and community leaders.
- 8 **Endline participant identification:** Updated HEW lists of pregnant women were used to randomly select women using computer-generated random numbers by JK in March 2019. JK was not blind to allocation status but was not involved in participant or cluster recruitment, intervention delivery or outcome assessments. Lists of selected women were shared with field supervisors shortly before data collection began.
- 9 **Endline participant recruitment:** Data collectors blind to allocation status and study hypotheses recruited randomly selected women in a similar process to that described for baseline.

Figure 7.2. Timeline cluster diagram illustrating participant recruitment, randomization, outcome assessments and blinding status of the trial.

Identification and recruitment of clusters as well as identification of women for the baseline survey occurred prior to randomization, making identification bias unlikely. Once MWH⁺'s upgrading was completed and leader activities commenced, providers (ex: health centre staff, HEWs) and participants (women) across the study area may have been aware of their cluster's allocation status depending on the extent of their interaction with health centres and each other. The risk of contamination through leaders in the control arm encouraging their congregation to deliver at health facilities, as well as performance bias from being aware of allocation to the intervention arms cannot be precluded.

7.2.3.6. Data collection and outcome measures

The primary outcome was institutional birth defined as delivery of the last child at a health facility where obstetric care is provided (i.e., health centre or hospital) as reported by an enrolled woman. Secondary outcomes included antenatal care (self-reported antenatal care received for last child delivered) and postnatal care (self-reported postnatal care received for last child delivered within 48 hours and upto 6 weeks). Outcomes were measured at baseline and 21 months after the introduction of interventions ("endline") through household surveys. Data were collected using interviewer-administered questionnaires in Afaan Oromo or Amharic which contained sections on socio-demographics, reproductive history, attitudes towards and use of maternal health care service use including MWHs, danger sign knowledge and social support. The questionnaire was adapted based on the Ethiopia Demographic Health Survey(40) and the JHPIEGO birth preparedness and complication readiness monitoring tool kit (41); the MWH module was developed by the research team (Supplement 1).

7.2.3.7. Protocol amendments

The protocol specified that endline data collection would take place 24 months after the introduction of the interventions. However, due to delays in intervention rollout experienced due to political instability in the country, endline outcomes were assessed after a shorter duration of intervention exposure. Similarly, resource and time constraints necessitated the cancellation of an additional round of data collection (midline survey). This resulted in the need to increase the minimum absolute detectable difference in institutional births from 15% as planned, to 17% to maintain prespecified sample size and power.

7.2.3.8. Analysis

An intention to treat approach was used for primary analysis where original cluster assignments to trial arms were maintained regardless of whether interventions were delivered or not. Institutional births were compared at endline between intervention and control groups using a generalized linear mixed model. The model included a random intercept for PHCU to account for within-period ICC as

well as a random cluster-period effect to account for the between-period ICC.(33) Differences at baseline were constrained by including fixed effects for time and intervention by time. The Kenward-Roger degrees of freedom approximation was used to account for bias due to the relatively small number of clusters included in the trial.(42) Secondary outcomes, namely postintervention antenatal care and postnatal care use, were analysed as described for the primary outcome. Odds ratios with 97.5% confidence intervals (two-sided alpha of 0.025 used) were used to report comparisons between intervention groups and control. The ICCs for outcomes were calculated on the proportions scale. Data analysis was conducted in STATA version 15 and SAS version 9.4.

Although not specified in the trial protocol, frequency tables, descriptive statistics and graphs were generated to contextualize the findings on the impact of the interventions on institutional births. The intervention components were expected to increase the levels of institutional births by improving awareness and use of functional MWHs and enhancing women's access to facility obstetric care by mobilizing community support in tackling barriers. Thus, four main areas were explored: (i) awareness of MWHs, (ii) appropriate linkage of women to MWHs, (iii) use of MWHs and obstetric services, and (iv) quality of MWH services as part of ancillary analyses.

7.2.4. Results

7.2.4.1. Baseline characteristics of participants

All 24 randomly selected PHCUs received their respective treatment allocations and were included in the analysis (Figure 7.3). The average observed cluster sample size at baseline ranged from 143 in control PHCUs to 171 in training only PHCUs. This difference was partially due to the replacement of ineligible women from one PHCU with pre-selected replacements from other PHCUs when replacements ran out. Data on institutional births were available for all enrolled women at baseline and endline apart from those who had abortions as pregnancy outcomes.

Slightly less than 50% of women in the study area PHCUs had some level of education; most women were housewives and had more than one child (Table 7.1). Their husbands generally engaged in farming and about half had a primary school education. The majority of households reported being within an hour of a health facility. Clusters were comparable across most characteristics. Clusters in the leader training arm had a slightly higher proportion of educated women when contrasted with the MWH⁺ & training or usual care arms. ANC and PNC use as well as institutional birth levels in leader training PHCUs was also slightly higher than the other two groups but this difference was not statistically significant (data not shown). Poorly functional MWHs were also mainly found in the

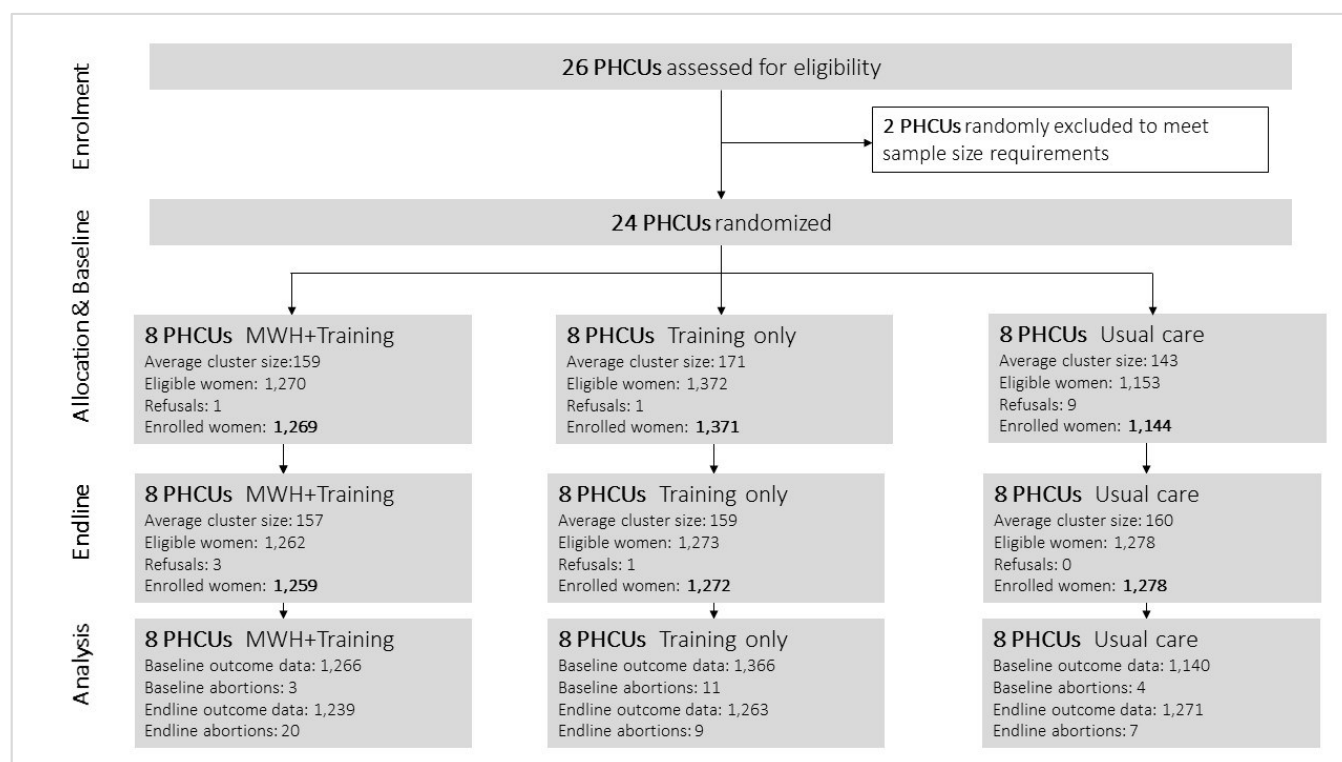


Figure 7.3. CONSORT participant flow diagram

MWH⁺ & training and usual care arms.

7.2.4.2. Post-intervention institutional births

The proportion of institutional births in the study area increased across all groups between baseline and endline (Table 7.2). While both the combined intervention (OR=1.09, CI: 0.67 to 1.75) and training alone (OR=1.37, CI: 0.85 to 2.22) slightly improved institutional births compared to usual care, the increases were not statistically significant.

Increases between baseline and endline were also noted for both ANC and PNC use. However, there was no difference in ANC use between PHCUs in the combined intervention group compared to usual care (OR=0.99, CI: 0.59 to 1.66). The increased ANC use in the training only group compared to usual care was not statistically significant (OR=1.38, CI: 0.80 to 2.38). Neither interventions had a significant effect on PNC use.

Table 7.1. Baseline characteristics of clusters and individuals by trial arm

Participant characteristics	MWH ⁺ & training (n=1,269)		Training only (n=1,371)		Usual care (n=1,144)		Overall (n=3,784)	
Cluster level								
Mean PHCU sample size (Standard deviation)	159 (15)		171 (41)		143 (20)		158 (29)	
PHCU sample size range	136 - 189		116 - 242		111 - 166		111 - 242	
	n	(%)	n	(%)	n	(%)	n	(%)
Educated women	550	(44.0)	677	(50.0)	456	(40.0)	1,683	(45.0)
Least poor households	593	(47.0)	569	(43.0)	351	(31.0)	1,513	(40.0)
Poor functioning MWH	6	(75.0)	3	(38.0)	7	(88.0)	16	(67.0)
≥1 BEmOC trained midwife	6	(75.0)	8	(100)	7	(88.0)	21	(88.0)
HEW home visit	418	(32.9)	477	(34.8)	375	(32.8)	1,270	(33.6)
Antenatal care use	1,052	(82.9)	1,215	(88.6)	911	(79.6)	3,178	(84.0)
Maternity waiting home use	98	(7.7)	88	(6.4)	70	(6.1)	256	(6.8)
Institutional births	608	(48.0)	726	(53.2)	519	(45.5)	1,853	(49.1)
Postnatal care use	491	(38.8)	576	(42.2)	421	(36.9)	1,488	(39.4)
Individual level								
Women's age	n	(%)	n	(%)	n	(%)	n	(%)
<20 years	84	(6.9)	102	(7.6)	62	(5.6)	248	(6.8)
20 – 30 years	790	(65.0)	862	(64.1)	705	(63.5)	2,357	(64.2)
> 30 years	342	(28.1)	381	(28.3)	344	(31.0)	1,067	(29.0)
Women's occupation								
Housewives	980	(77.2)	1,064	(77.6)	890	(77.8)	2,934	(77.5)
Other	289	(22.8)	307	(22.4)	254	(22.2)	850	(22.5)
Parity								
1 child	274	(21.6)	329	(24.0)	224	(19.6)	827	(21.9)
> 1 child	995	(78.4)	1,042	(76.0)	920	(80.4)	2,957	(78.1)
Husband's education level								
None	562	(47.0)	508	(38.9)	506	(46.5)	1,576	(43.9)
Primary	530	(44.3)	659	(50.5)	493	(45.3)	1,682	(46.9)
Secondary/higher	104	(8.7)	138	(10.6)	89	(8.2)	331	(9.2)
Husband's occupation								
Farmer	982	(82.2)	1,085	(83.4)	950	(87.6)	3,017	(84.3)
Other	212	(17.8)	216	(16.6)	135	(12.4)	563	(15.7)
Travel time to health centre ¹								
< 1 hour	914	(75.7)	1,059	(79.3)	854	(78.4)	2,827	(77.9)
≥ 1 hour	293	(24.3)	276	(20.7)	235	(21.6)	804	(22.1)

¹ The majority of women reported walking to health centres (approx. 88%). About 10% used motorized transport while the rest relied on bicycles or animals.

Table 7.2. Effectiveness of interventions on improving institutional births and secondary outcomes (ANC, PNC)

	MWH ⁺ & Training n (%)		Training only n (%)		Usual care n (%)		Overall n (%)	
Institutional births	(B) n=1,266 (E) n=1,239		(B) n=1,366 (E) n=1,263		(B) n=1,140 (E) n=1,271		(B) n=3,772 (E) n=3,773	
Baseline births	608	(48.0)	726	(53.2)	519	(45.5)	1,853	(49.1)
Endline births	671	(54.2)	821	(65.0)	646	(50.8)	2,138	(56.7)
Odds ratio ¹ (97.5% CI)	1.09 (0.67 to 1.75)		1.37 (0.85 to 2.22)		Reference			
ICCs	Within-period ICC = 0.1098 Between period ICC = 0.0912 Cluster autocorrelation coefficient = 0.831							
Antenatal care	(B) n=1,269 (E) n=1,259		(B) n=1,371 (E) n=1,272		(B) n=1,144 (E) n=1,278		(B) n=3,784 (E) n=3,809	
Baseline use	1,052	(82.9)	1,215	(88.6)	911	(79.6)	3,178	(84.0)
Endline use	1,081	(85.9)	1,176	(92.5)	1,056	(82.6)	3,313	(87.0)
Odds ratio (97.5% CI)	0.99 (0.59 to 1.66)		1.38 (0.80 to 2.38)		Reference			
ICCs	Within-period ICC = 0.0764 Between period ICC = 0.0624 Cluster autocorrelation coefficient = 0.816							
Postnatal care	(B) n=1,266 (E) n=1,239		(B) n=1,366 (E) n=1,263		(B) n=1,141 (E) n=1,271		(B) n=3,773 (E) n=3,773	
Baseline use	491	(38.8)	576	(42.2)	421	(36.9)	1,488	(39.4)
Endline use	526	(42.5)	649	(51.4)	564	(44.4)	1,739	(46.1)
Odds ratio (97.5% CI)	0.88 (0.55, 1.39)		1.05 (0.66, 1.67)		Reference			
ICCs	Within-period ICC =0.0828 Between period ICC = 0.0678 Cluster autocorrelation coefficient = 0.819							

(B): Baseline (E): Endline

¹ Odds ratio refers to between-arm difference controlling for baseline

7.2.4.3. Ancillary analyses

7.2.4.3.1. Awareness about MWH services and benefits

As shown in Figure 7.4a, awareness about the existence of MWHs, knowing someone who had used the services, awareness of benefits associated with MWH stay and women's ability to link MWH stay with easier access to skilled obstetric care was lower in endline compared to baseline; however, there were no significant differences between trial arms during either survey round. HEWs and nurses were reported to be sources of information for over 50% of women surveyed during endline. Less than

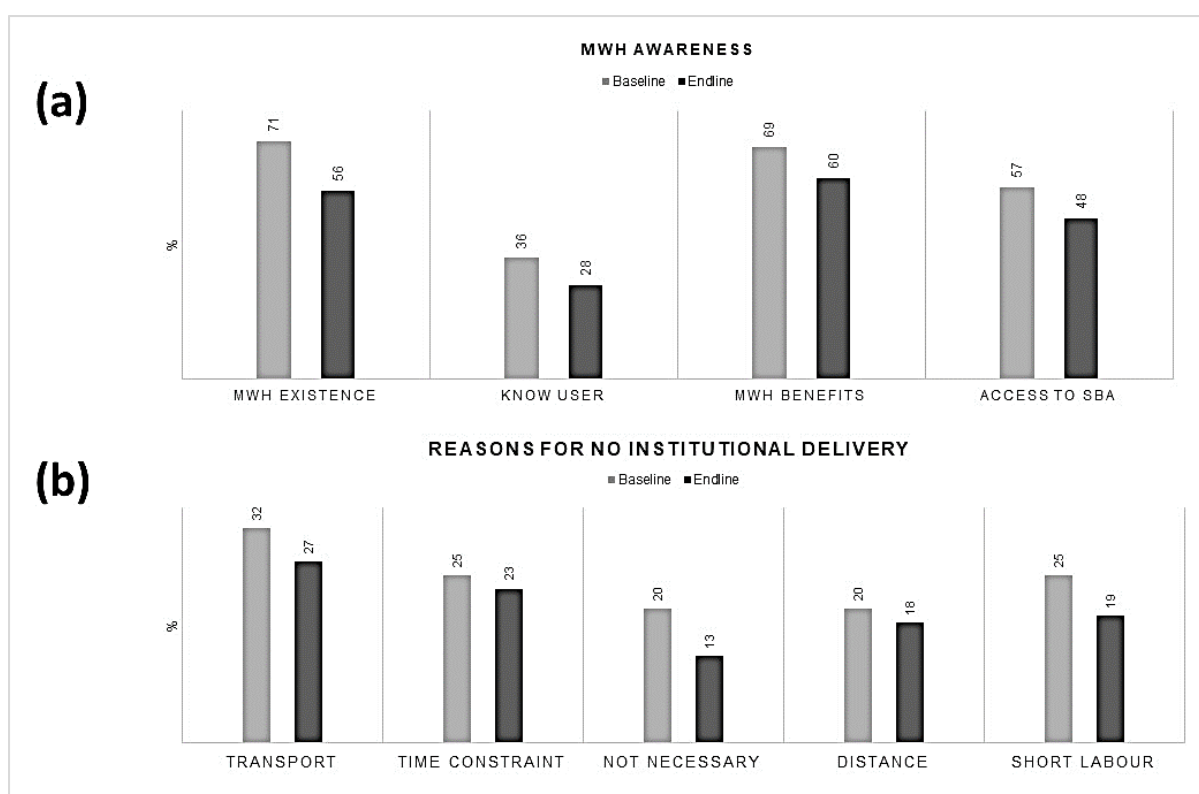


Figure 7.4. Bar charts of (a) dimensions of MWH awareness among women (b) reasons for no institutional delivery

1% of women relied on WDA for health information (such as danger signs during pregnancy) and none of the women surveyed cited religious leaders as a source. HEW contact with families through home visits was similar between baseline and endline (34% vs. 32%) and was not significantly different between trials arm at endline.

7.2.4.3.2. Linking women to MWHs

Very few women interviewed during the surveys reported getting an MWH referral as part of their birth preparedness planning. During endline, over 75% of MWHs users were referred by HEWs or midwives in intervention arms compared to about half in the control arm but the difference was not statistically significant (p-value 0.097). Obtaining a referral represented about 32% of responses to questions about reasons for MWH stay and was significantly higher in the MWH⁺ & training arm (47%) compared to usual care (12%, p-value 0.0292). Expecting complications (34%), large distances between home and health facility (33%) and needing rest (23%) formed a large part of other reasons for MWH stay.

7.2.4.3.3. Use of MWH and obstetric services

Overall, MWH use was higher at baseline (6.7%, n=256/3,784) than endline (5.8%, n=219/3,809). MWH utilization in the MWH⁺ & training arm was low with less than five women surveyed reporting MWH use in five of the eight PHCUs. Moreover, there was no significant difference in MWH use (p-value 0.6343) at endline between the intervention (MWH⁺ & training 6.4% n=80/1,259; training only 4.6% n=58/1,272) and control arms (6.3%, n=81/1,278). About 40% of non-users cited a lack of awareness as their reason for not using an MWH while living too close to need one was described by 27% of non-users during endline; neither reasons were significantly different between trial arms. Nevertheless, four intervention sites had over 55% of non-users reporting a lack of awareness about MWHs. Reasons related to concerns around quality of services, prior bad experiences or hearing bad reviews from other women were uncommon (1% - 4%). Similarly, access-related issues such as high transport costs (<1%) and social factors like no childcare (4%) or getting resistance from family members (2%) were described by only a small proportion of non-users.

Overall, 51% (n=1,919/3,772) of women at baseline did not give birth at a health facility; this decreased to 43% (n=1,635/3,773) at endline. The most commonly cited barrier among women during both survey rounds (Figure 7.4b) was lack of transport, followed by time constraints and large distances between facilities and homes. Almost half the women who mentioned distance as a barrier were unaware of MWH services. The proportion of women who felt giving birth at facilities was unnecessary because they were healthy or had previous successful home births dropped from 20% in baseline to 13% in endline. However, only the transport barrier was significantly different between trial arms (34% MWH⁺ & training, 21% training arm, 27% usual care) at endline (p-value 0.0384). About 50% of respondents during both baseline and endline reported having a health centre within or close to their area of residence, but there was no significant difference between trial arms. However, there were significant differences between clusters during both periods. During baseline 40% of women reported walking to the health facility for their last delivery, 30% relied on ambulance services and 22% used some form of motorized transport; during endline the use of motorized transport increased to 31%, but there was no significant difference between trial arms in mode of transport at endline (p-value 0.6845). The fraction of women living with 30 minutes of a health facility was similar between baseline and endline (71% vs 74%); and although in endline a slightly higher proportion lived more than 30 minutes away in the MWH⁺ & training (31%) and control arms (28%) compared to the leader training only arm (20%), the difference was not significant (p-value 0.0689).

While increases in MWH use generally coincided with increases in institutional births across all three arms (Figure 7.5), a few PHCUs experienced increases in institutional births while MWH use declined between baseline and endline. In Adere Dika (MWH⁺&training arm) for instance, MWH use dropped by 10% but institutional births increased by 10%; over 40% of non-users reported short distances to health facilities as their reason for not choosing to use MWHs. A similar response was also observed in two PHCUs in the training-only arm (Setemma and Seka).

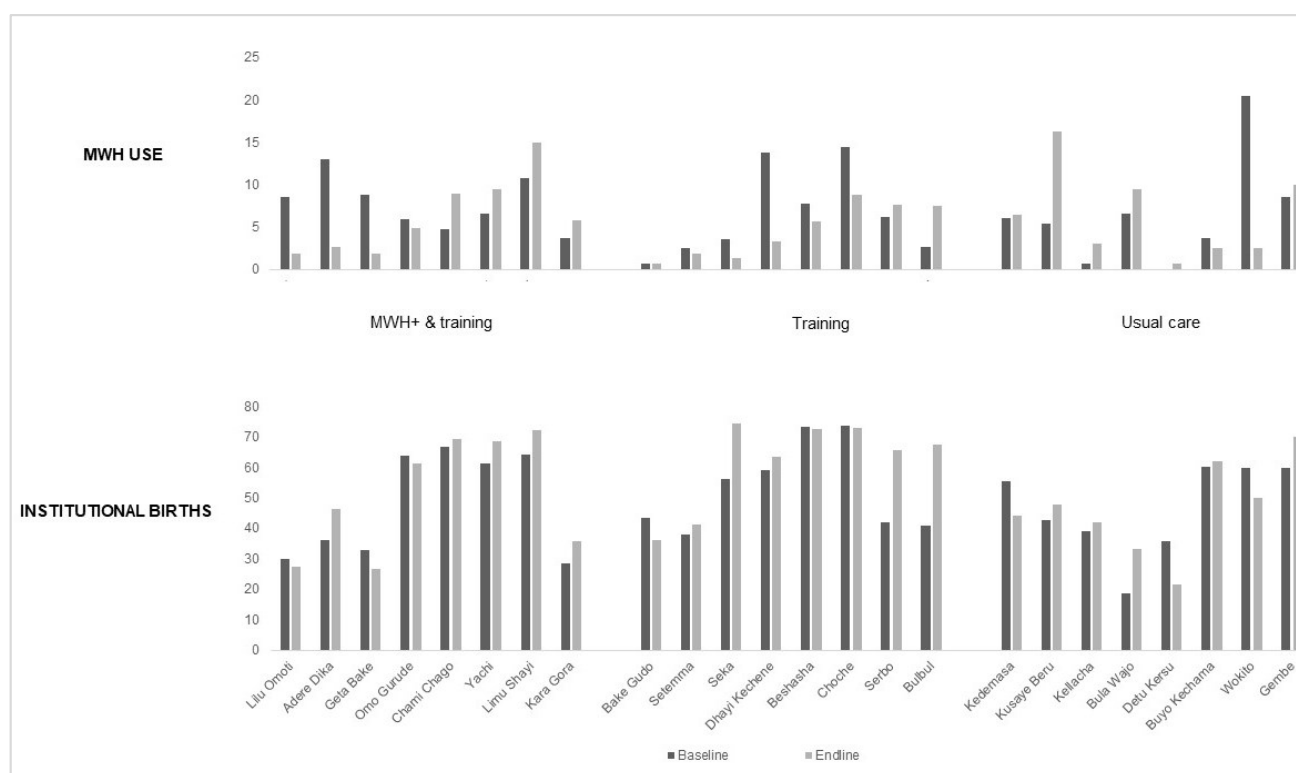


Figure 7.5. Bar chart of MWH use and institutional births across PHCUs and over survey periods.

7.2.4.3.4. Quality of services

Satisfaction with health facilities in general appeared to be slightly higher during baseline than endline (positive ratings: 82% vs. 73%); the differences in quality ratings between trial arms during endline (74% MWH⁺& training, 78% training and 68% control) were statistically significant (p-value 0.0434). However, while the majority of combined intervention arm MWHs were reported to have provided beds/bedding and food or cooking facilities, very few users were checked on by midwives (21%), had access to toilets and clean water (16%) or bathrooms (14%). Despite this, all MWH⁺& training users said they would recommend MWH stay to other women. Notably, Kusaye Beru in the control arm registered high performance in terms of number of services received by users.

7.2.5. Discussion

The combination of upgraded MWHs and leader training lead to small but non-significant improvements in institutional birth levels in Jimma Zone. One reason for this lack of effect may have been low exposure to the interventions due to security concerns in the country during the trial period. A state of emergency was declared in Ethiopia in 2016 and in 2018.(43,44) Political unrest, particularly in Oromia region, may have hampered leaders' abilities to conduct planned activities and women's safe access to interventions. This may partially explain the lack of difference in awareness of MWH services and benefits across trial arms although intervention arms would have been expected to have higher awareness level. Higher community acceptance and use of MWHs in Ethiopia has been credited to better awareness about MWH services and associated benefits.(14) WDA community leaders may also have experienced personal challenges in conducting community activities as research from Amhara region found that WDAs had poor living conditions, suffered from food insecurity and debt and were not able to access the government resources they hoped for when joining the WDA.(45) The voluntary nature of the WDA has also been reported to hamper efforts by HEWs who often rely on WDAs to link women to services.(46) The consideration of MWHs as part of birth preparedness planning was very low, suggesting a need to better promote MWHs as a means to overcome distance and transport barriers. Family Conversations, for instance, conducted by HEWs to engage families to better prepare for delivery(47) would be a useful platform to broaden conventional delivery plans which traditionally focus on saving money for transport and calling ambulances.

In this context women relied heavily on HEW referrals to gain entry to MWHs. Referral activities appeared to be significantly higher in the intervention arms compared to control suggesting HEWs participating in the intervention arms were encouraging women to use MWHs. Still, it was likely that referral activities had not reached optimal levels with only one-third of women reporting home visits by HEWs across all three arms at endline. This could mean that women who were not able to come to a health post for services may not have been referred to MWHs by HEWs; a study on how HEWs use their time at work reported they spend 25% of their day waiting for clients at the health post and about 35% on administrative tasks and travel.(48) Despite only 12% of non-users in this trial citing no referrals as the reason for not using an MWH, more investigation is needed on HEW referral practices; in particular, to whom HEWs promote MWHs to since they are the most common source of health information for women and an important link to health services in this setting and elsewhere in Ethiopia.(49) Data on compliance to MWH referrals by women is also needed to distinguish between low use due to deficient referral levels versus minimal compliance. A study in Kenya reporting low MWH use recommended follow up of women referred to MWHs as high referral rates were not matching utilization levels.(50)

Low MWH use has often been linked to the poor quality of services offered. Only 15% of women in endline from the MWH⁺ & training arm who did not use MWHs said it was because they were dissatisfied with the quality of services. The majority of MWH users in this arm reported receiving bedding and meals. However, access to toilets, water and bathrooms was low. Monitoring of MWH users by midwives was also reported by just one-third of users. While midwives were briefed on use of MWH registers and their continued role in referring women to MWHs, they were not provided additional training as part of the intervention. While it is unlikely that upgraded MWHs increased delivery workloads substantially as reported in other settings (51), more engagement with midwives may have improved levels of MWH user monitoring.

Another important reason for low MWH use among some women may have been a relatively short distance between homes and health facilities making direct access to the facility possible. Travel time and distance have been reported to be inversely correlated with MWH use.(23,52) Almost half of the women in endline who had not used an MWH said they lived close to the facility. Almost three-quarters of women reported living within 30 minutes of a health facility which could possibly make MWHs as a solution to physical inaccessibility unnecessary for them. Despite this, distance as a barrier to delivering at a health facility persists as a reason for delivering at home. There is, therefore, a need to establish how far from health facilities women need to reside for MWHs to be most beneficial to them to better gauge unmet need.

7.2.5.1. Strengths and limitations

One of the main strengths of the trial and intervention design were that they adopted a pragmatic approach to reflect conditions in which interventions were intended for use outside of a research setting. (53) Using an “integrative ecological paradigm” recognizes that community interventions are a part of “larger complex systems” and can “disrupt or enhance existing community resources”; they generally aim to expand local capacity.(54) Intervention design in this trial focused on improving existing MWHs without diminishing established community contributions. Engaging HEWs as co-facilitators for leader training built on their roles as community leaders, critical links between the community and the health system and trusted sources of information.(34,55) Indeed, empowering religious leaders and WDA members to design engagement activities leveraged their influence within the communities while reinforcing their leadership roles. Partnering with Jimma Zone administration led to interventions designed not only to incorporate end-user preferences but also included improvements that were aligned with what policymakers expected could be feasibly scaled.

The improvement in outcomes across all arms including usual care made it difficult to detect an improvement due to the interventions, compounded by the fact that the difference was smaller than anticipated. Without examination of process data generated through qualitative work and project monitoring, it is difficult to assess the extent of intervention delivery. A limitation in this paper, therefore, is the inability to distinguish between small effect due to implementation issues resulting in lower intervention exposure and an ineffective intervention. While the security situation reduced the team's ability to conduct all planned monitoring visits, the available data will be analysed separately to assess the range of activities conducted by trained local leaders to understand why the training-only arm had an unexpectedly higher effect than the combined intervention. Both monitoring and qualitative data sources will also be useful in uncovering any co-interventions that may have occurred and diminished the intervention's effects as well as shed light on contextual factors that could explain the patterns in MWH use and institutional births observed between PHCUs. It will be interesting to see if increases in institutional births in PHCUs with declines in MWH use were as a result of locally created solutions that improved access to delivery care but did not require women to be absent from their homes a few weeks before delivery.

A second important limitation was the relatively short duration of intervention exposure that may have been insufficient enough to observe any significant changes in the communities and in women's behaviours. Complex interventions, that do not necessarily exhibit linear causality from input to outcome and engage "active agents" with adaptable behaviours, often require several years of implementation time.(56) In fact, a review on evaluating the effectiveness of behaviour change techniques described trial timescales as typically being at least three years long.(57)

Finally, if a specific distance cut-off had been included in the participant eligibility criteria, it may have focused the evaluation on women who may be experiencing geographical barriers. However, the distance relevant to this setting has yet to be established given the large proportion of households located within an hour of a health facility.

7.2.6. Conclusions

While only a small effect on institutional births was found from introducing upgraded MWHs and training local leaders, the trial findings point to the importance of integrating engagement of communities and health workers along with quality improvements to MWHs. Without improved community awareness and support for MWHs and the presence of effective referral mechanisms to link women to these services, quality improvements may be insufficient to improve utilization rates and ultimately increase institutional births. Moreover, though flexibility in intervention activities is

important for tailoring solutions to local circumstances, consistent supportive supervision may be needed to encourage successful delivery of interventions.

7.2.7. List of abbreviations

ANC:	Antenatal care
BEmOC:	Basic emergency obstetric care
CI:	Confidence interval
HEW:	Health extension worker
ICC:	Intraclass correlation coefficient
JZHO:	Jimma Zone Health Office
MWH:	Maternity waiting home
OR:	Odds ratio
PHCU:	Primary health care unit
PNC:	Postnatal care
WDA:	Women's Development Army

7.2.8. Declarations

7.2.8.1. Ethics approval and consent to participate

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File No: H10-15-25B and the Jimma University College of Health Sciences Institutional Review Board (Ref No: RPGE/449/2016). Verbal informed consent for data collection was obtained from eligible women willing to participate in interviews prior to each round of household surveys. Verbal informed consent was approved by the ethics committees due to the relatively low literacy rate in the study area. Trained research assistants read out the contents of the consent forms outlining the survey objectives, institutions and investigators involved and describing what was expected of women as well as associated risks and benefits. This was done in a local language of women's choice (Amharic or Afaan Oromo). Women were also explained their rights as participants and their questions answered prior to enrolment. Clusters were randomized before women were recruited for surveys; therefore, it was not possible to obtain consent from women for receiving study interventions as these were delivered at community level. However, use of MWHs and engaging with local leaders was voluntary.

7.2.8.2. *Consent for publication*

Not applicable

7.2.8.3. *Availability of data and materials*

Data used for this analysis will be provided by the authors upon reasonable request to the principal investigator, Dr. Manisha Kulkarni.

7.2.8.4. *Competing interests*

None declared

7.2.8.5. *Funding*

This work was carried out with the aid of a grant from the Innovating for Maternal and Child Health in Africa initiative- a partnership of Global Affairs Canada (GAC), the Canadian Institutes of Health Research (CIHR) and Canada's International Development Research Centre (IDRC). The funders played no role in study design, data collection, analysis and interpretation or manuscript writing.

7.2.8.6. *Authors' contributions*

MK, RL, LA & SM conceptualized the study with input from KHB, GB & MAW; MK led overall trial design; MT & JK contributed to details of trial design and specified trial analysis. JK and MA created data collection tools with input from MK, LAG and SM; AM created the social support module. MK, KBH, GB, LA, SM, MA, RL and JK were involved in designing the MWH intervention. JK, MK and MT conducted quantitative data analysis. JK, LAG, MAW, SM, KHB, GB, NB, GK, YA, SA, AM, EE, KT, RL, MT and MK interpreted findings. JK wrote the first draft of the manuscript that was subsequently finalized with input from LAG, MAW, SM, KHB, GB, NB, GK, YA, SA, AM, EE, KT, RL, MT and MK. All authors have read and approved the manuscript.

7.2.8.7. *Acknowledgments*

We are grateful to the communities who have been generous with their time and thoughts and without whom this trial would not be possible. We express appreciation to Dr. Donald Cole who provided useful comments to improve the manuscript. Finally, we would like to acknowledge Dr. Corinne Packer for project management, Gemechu Abene for local study coordination and the entire team of data collectors who walked for days to interview participants in random spots across the study area.

7.2.9. Article References

1. World Health Organization. Maternity Waiting Homes: A review of experiences. Geneva; 1996.
2. World Health Organization. Trends in Maternal Mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank and UN Population Division. Geneva; 2019.
3. Central Statistical Agency, The DHS Program ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa and Rockville, Maryland; 2017.
4. Kebede A, Hassen K, Teklehaymanot AN. Factors associated with institutional delivery service utilization in Ethiopia. *Int J Womens Health*. 2016;8:463–75.
5. Bayu H, Fisseha G, Mulat A, Yitayih G, Wolday M. Missed opportunities for institutional delivery and associated factors among urban resident pregnant women in South Tigray Zone, Ethiopia: a community-based follow-up study. *Glob Health Action*. 2015;8:28082.
6. Arba MA, Darebo TD, Koyira MM. Institutional Delivery Service Utilization among Women from Rural Districts of Wolaita and Dawro Zones , Southern Ethiopia ; a Community Based Cross-Sectional Study. *PLoS One*. 2016;11(3):e0151082.
7. Demilew YM, Gebregergs GB, Negusie AA. Factors associated with institutional delivery in Dangila district, North West Ethiopia: A cross-sectional study. *Afr Health Sci*. 2016;16(1):10–7.
8. Feyissa TR, Genemo GA. Determinants of institutional delivery among childbearing age women in Western Ethiopia, 2013: Unmatched case control study. *PLoS One*. 2014;9(5):1–7.
9. Hailu D, Berhe H. Determinants of institutional childbirth service utilisation among women of childbearing age in urban and rural areas of Tsegedie district, Ethiopia. *Midwifery*. 2014;30:1109–17.
10. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes*. 2015;8(376).
11. Yebyo HG, Gebreselassie MA, Kahsay AB. Individual and community-level predictors of home delivery in Ethiopia: A multilevel mixed-effects analysis of the 2011 Ethiopia National Demographic and Health Survey. *DHS Working Papers No. 104*. 2014.
12. Fikre AA, Demissie M. Prevalence of institutional delivery and associated factors in Dodota Woreda (district), Oromia regional state, Ethiopia. *Reprod Health*. 2012;9(33).
13. Wilunda C, Quaglio G, Putoto G, Takahashi R, Calia F, Abebe D, et al. Determinants of utilisation of antenatal care and skilled birth attendant at delivery in South West Shoa Zone, Ethiopia: a cross sectional study. *Reprod Health*. 2015;12(74).
14. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
15. Ethiopian Public Health Institute, Federal Ministry of Health Ethiopia, Columbia University. Ethiopian Emergency Obstetric and Newborn Care (EmONC) Assessment 2016. 2017.
16. Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa; 2015.
17. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
18. Chandramohan D, Cuttsa F, Chandrab R. Effects of a maternity waiting home on adverse maternal outcomes and the validity of antenatal risk screening. 1994;46:279–84.
19. Chandramohan D, Cutts F, Millard P. The effect of stay in a maternity waiting home on perinatal

- mortality in rural Zimbabwe. *J Trop Med Hyg.* 1995 Aug;98(4):261–7.
20. Tumwine JK, Dungare PS. Maternity waiting shelters and pregnancy outcome: experience from a rural area in Zimbabwe. *Ann Trop Paediatr.* 1996 Mar;16(1):55–9.
 21. Braat F, Vermeiden T, Getnet G, Schiffer R, van den Akker T, Stekelenburg J. Comparison of pregnancy outcomes between maternity waiting home users and non-users at hospitals with and without a maternity waiting home: retrospective cohort study. *Int Health.* 2018;10:47–53.
 22. Bonawitz R, Mcglasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia : A mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS One.* 2019;14(11):e0225523.
 23. Kurji J, Gebretsadik LA, Wordofa MA, Sudhakar M, Asefa Y, Kiros G, et al. Factors associated with maternity waiting home use among women in Jimma Zone , Ethiopia : a multilevel cross-sectional analysis. *BMJ Open.* 2019;9(e028210).
 24. Tiruneh GT, Taye BW, Karim AM, Betemariam WA, Zemichael NF, Wereta TG, et al. Maternity waiting homes in Rural Health Centers of Ethiopia: The situation, women's experiences and challenges. *J Heal Dev.* 2016;30(1):19–28.
 25. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: Women's beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health.* 2015;12(61).
 26. Kyokan M, Whitney-long M, Kuteh M, Raven J. Community-based birth waiting homes in Northern Sierra Leone: Factors influencing women's use. *Midwifery.* 2016;39:49–56.
 27. Bergen N, Abebe L, Asfaw S, Kiros G, Kulkarni MA. Maternity waiting areas – serving all women ? Barriers and enablers of an equity-oriented maternal health intervention in Jimma Zone, Ethiopia. *Glob Public Health.* 2019;14(10):1509–23.
 28. Kurji J, Kulkarni MA, Gebretsadik LA, Wordofa MA, Morankar S, Bedru KH, et al. Effectiveness of Upgraded Maternity Waiting Homes and Local Leader Training in Improving Institutional Births among Women in Jimma Zone, Ethiopia: study protocol for a cluster randomized controlled trial. *Trials.* 2019;20(671).
 29. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2016.
 30. Jimma Zone Health Office. Jimma Zone Annual Health Bulletin. Jimma; 2019.
 31. Assefa Y, Gelaw YA, Hill PS, Taye BW, Damme W Van. Community health extension program of Ethiopia , 2003 – 2018 : successes and challenges toward universal coverage for primary healthcare services. 2019;1–11.
 32. Pagel C, Prost A, Lewycka S, Das S, Colbourn T, Mahapatra R, et al. Intraclass correlation coefficients and coefficients of variation for perinatal outcomes from five cluster-randomised controlled trials in low and middle-income countries: results and methodological implications. *Trials.* 2011;12(151).
 33. Hooper R, Forbes A, Hemming K, Takeda A, Beresford L. Analysis of cluster randomised trials with an assessment of outcome at baseline. *BMJ.* 2018;360(k1121).
 34. Mamo A, Morankar S, Asfaw S, Bergen N, Kulkarni MA, Abebe L, et al. How do community health actors explain their roles ? Exploring the roles of community health actors in promoting maternal health services in rural Ethiopia. *BMC Health Serv Res.* 2019;7(24).
 35. Bohren MA, Hunter EC, Munthe-Kaas HM, Souza J, Vogel JP, Gülmezoglu A. Facilitators and barriers to facility-based delivery in low- and middle-income countries: a qualitative evidence synthesis. *Reprod Health.* 2014;11(71).
 36. Moyer CA, Mustafa A. Drivers and deterrents of facility delivery in sub-Saharan Africa: a

- systematic review. *Reprod Health*. 2013;10(40).
37. Gabrysch S, Campbell OMR. Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy Childbirth*. 2009;9(34).
 38. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. *BMC Pregnancy Childbirth*. 2014;14(161).
 39. Caille A, Kerry S, Tavernier E, Leyrat C, Eldridge S, Giraudeau B. Timeline cluster : a graphical tool to identify risk of bias in cluster randomised trials. *BMJ*. 2016;354(i4291).
 40. The DHS Program. DHS Model Questionnaire [Internet]. 2015 [cited 2016 Jan 7]. Available from: <https://dhsprogram.com/publications/publication-dhsq7-dhs-questionnaires-and-manuals.cfm>
 41. JHPIEGO. Monitoring birth preparedness and complication readiness: tools and indicators for maternal and newborn health programs [Internet]. 2004 [cited 2016 Feb 18]. Available from: <http://resources.jhpiego.org/resources/monitoring-birth-preparedness-and-complication-readiness-tools-and-indicators-maternal-and>
 42. Kenward MG, Roger JH. Small Sample Inference for Fixed Effects from Restricted Maximum Likelihood. *Biometrics*. 1997;53(3):983–97.
 43. Ethiopia declares state of emergency amid protests [Internet]. BBC World News. 2016. Available from: <https://www.bbc.com/news/world-africa-37600225>
 44. Why has Ethiopia imposed a state of emergency [Internet]. BBC World News. 2018. Available from: <https://www.bbc.com/news/world-africa-43113770>
 45. Maes K, Closser S, Tesfaye Y, Gilbert Y, Abesha R. Volunteers in Ethiopia's women's development army are more deprived and distressed than their neighbors:cross- sectional survey data from rural Ethiopia. *BMC Public Health*. 2018;18(258).
 46. Kok MC, Kea AZ, Datiko DG, Broerse JEW, Dieleman M, Taegtmeyer M, et al. A qualitative assessment of health extension workers' relationships with the community and health sector in Ethiopia: opportunities for enhancing maternal health performance. *Hum Resour Health*. 2015;13(80).
 47. Altaye DE, Karim AM, Betemariam W, Zemichael NF, Shigute T, Scheelbeek P. Effects of family conversation on health care practices in Ethiopia : a propensity score matched analysis. *BMC Pregnancy Childbirth*. 2018;18 (Suppl(372).
 48. Tilahun H, Fekadu B, Abdisa H, Canavan M, Linnander E, Bradley EH, et al. Ethiopia's health extension workers use of work time on duty : time and motion study. *Health Policy Plan*. 2017;32:320–8.
 49. King R, Jackson R, Dietsch E, Hailemariam A. Barriers and facilitators to accessing skilled birth attendants in Afar region, Ethiopia. *Midwifery*. 2015;31:540–6.
 50. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynaecol Obstet*. 2010;108:152–3.
 51. Kaiser JL, Fong RM, Ngoma T, McGlasson KL, Biemba G, Hamer DH, et al. The effects of maternity waiting homes on the health workforce and maternal health service delivery in rural Zambia:a qualitative analysis. *Hum Resour Health*. 2019;17(93).
 52. Sialubanje C, Massar K, Hamer DH, Ruiter RAC. Personal and environmental factors associated with the utilisation of maternity waiting homes in rural Zambia. *BMC Pregnancy Childbirth*. 2017;17(136).
 53. Byass P. The potential of community engagement to improve mother and child health in Ethiopia — what works and how should it be measured? *BMC Pregnancy Childbirth*. 2018;18

- (Suppl(366)).
54. Trickett EJ, Beehler S, Deutsch C, Green LW, Hawe P, McLeroy K, et al. Advancing the science of community-level interventions. *Am J Public Health*. 2011;101(8):1410–9.
 55. Asfaw S, Morankar S, Abera M, Mamo A, Abebe L, Bergen N, et al. Talking health: trusted health messengers and effective ways of delivering health messages for rural mothers in Southwest Ethiopia. *Arch Public Heal*. 2019;77(8).
 56. Moore GF, Evans R, Hawkins J, Littlecott H, Melendez-Torres G., Bonell C, et al. From complex social interventions to interventions in complex social systems : Future directions and unresolved questions for intervention development and evaluation. *Evaluation*. 2019;25(1):23–45.
 57. Michie S, West R, Sheals K, Godinho CA. Evaluating the effectiveness of behavior change techniques in health-related behavior: a scoping review of methods used. *TBM*. 2018;8:212–24.

Evaluation of Interventions to Promote Safe Motherhood in Jimma Zone, Ethiopia

QUESTIONNAIRE FOR INDEX WOMAN

INTERVIEWER: Complete this section before approaching household			
CP1	Interview date	USE ETHIOPIAN CALENDAR / / D D M M Y Y Y Y	CP16 Survey phase
CP2	Interviewer ID		CP3 Screening ID 7-DIGITS
CP4	Woman's first name		CP5 Woman's last name
CP17	District	¹ ☐ Gomma ² ☐ Seka Chekorsa ³ ☐ Kersa	
CP20	Survey site (PHCU)	ENTER PHCU WHERE TEAM IS GOMMA ¹ ☐ Beshasha ² ☐ Chami Chago ³ ☐ Choche ⁴ ☐ Dhayi Kechene ⁵ ☐ Gembe ⁶ ☐ Kedemasa ⁷ ☐ Limu Shayi ⁸ ☐ Omo Gurude ⁹ ☐ Yachi SEKA CHEKORSA ¹ ☐ Bake Gudo ² ☐ Buyo Kechema ³ ☐ Detu Kersu ⁴ ☐ Geta Bake ⁵ ☐ Lilu Omoti ⁶ ☐ Seka ⁷ ☐ Setemma ⁸ ☐ Wokito KERSA ¹ ☐ Adere Dika ² ☐ Bala Wajo ³ ☐ Bulbul ⁴ ☐ Kusaye Beru ⁵ ☐ Kara Gora ⁶ ☐ Kellacha ⁷ ☐ Serbo	
CP6	Kebele of residence	SEKA CHEKORSA ☐ Kusaro ☐ Ilke Tunjo ☐ Siba Qaqee ☐ Buyo Qacamaa ☐ Wokito Medaaluu ☐ Budo Keraa ☐ Andode Allaggee ☐ Xeebo Waacho ☐ Ilke Togobee ☐ Gibe Bosoo ☐ Deto Qarssu ☐ Bake Gudo ☐ Meexii ☐ BidaruTuulii ☐ Atro Sufaa ☐ Ushane Koche ☐ Ushane Buyo ☐ Dimtu Shekota ☐ Gura Ula'ukke ☐ Qoraa Waacoo ☐ Gaxa Bakke ☐ Shashamanne ☐ Meti Ushaane ☐ Geppa Sadan ☐ Magala Saqqaa ☐ Gudoo Daakaa ☐ Sakala Genefoo ☐ Dabo Yaya ☐ Komo Haarri ☐ Sogido ☐ D/Gibee ☐ Lili Ca'aa ☐ Sentema Goroo ☐ B/Rogee ☐ Nasee ☐ Geshe Lucine GOMMA ☐ Beshasha ☐ Bulado Choche ☐ Gomma 2 ☐ Bore dinsira ☐ Koye Sejja ☐ Gembe ☐ Keda maye ☐ Limu Shaye ☐ Omo Gobu ☐ Omo Funtule ☐ Limu Sapha ☐ Belfo Konche ☐ Kotta ☐ Keta Bero ☐ Keso Hiti ☐ Kedemasa ☐ Acha Afeta ☐ Yachi ☐ Getabore ☐ Meti Koticha ☐ Kilole ☐ Tesso Sadecha ☐ Dedessa ☐ Dedo Ureche ☐ Gogga Kamise GOMMA continued	

		☐ Barsoma ☐ Elbu ☐ Dalecho ☐ Chedero Suse ☐ Bulbulo ☐ Omo Gurude ☐ Omo Beko	☐ Gomma 1 ☐ Choche ☐ Choche Lemmi ☐ Dinu ☐ Gabene Abo	☐ Dhayi kechene ☐ Chami Chago ☐ Jimate Deru ☐ Odo Adami
CP6 cont.	Kebele of residence (continued)	KERSA ☐ Awaye Sebu ☐ Babo ☐ Tikur Balto ☐ Tikur Abulo ☐ Girma ☐ Serbo ☐ Toli Kersu ☐ Adere Dika ☐ Folla Gubeta ☐ Mara Kebericho	☐ Ankeso ☐ Gunju ☐ Kombolcha ☐ Merewa ☐ Kojja Mujja ☐ Bulbul ☐ Gello ☐ Kitimbile ☐ Wadiko ☐ Kusaye Beru ☐ Kellacha	☐ Busa Bechane ☐ Kersa sume ☐ Bala wajo ☐ Dogoso ☐ Osso ☐ Siba ☐ Sinkulle ☐ Kara Gora ☐ Shewa Totoba ☐ Gora Seriti
INTERVIEWER: Introduce yourself and follow consent procedures before enrolling woman				
CNST1	Woman eligible?	<i>INTERVIEWER: ask woman if she gave birth to a child, had a stillbirth or miscarriage/abortion during the past 12 months.</i> ¹ ☐ Yes ⁰ ☐ No SKIP TO END (Report to supervisor)		
CP8	Consent obtained?	¹ ☐ Yes ⁰ ☐ No SKIP TO END. Fill REFUSAL form		
CP10	Household ID	5-DIGITS 	CP9	6-DIGITS 1
CP11	Is woman's name correct?	¹ ☐ Yes SKIP TO CP12 ⁰ ☐ No		
CP11a	Woman's correct first name		CP11b	Woman's correct last name
CP12	Husband's first name		CP13	Husband's last name
CP7	Household GPS	Latitude ° ' " Longitude ° ' "		

CP18	Name of health centre woman attends	GOMMA ¹ ○ Beshasha ² ○ Chami Chago ³ ○ Choche ⁴ ○ Dhayi Kechene ⁵ ○ Gembe ⁶ ○ Kedemasa ⁷ ○ Limu Shayi ⁸ ○ Meti Koticha ⁹ ○ Omo Gurude ¹⁰ ○ Yachi	SEKA CHEKORSA ¹ ○ Bake Gudo ² ○ Buyo Kechema ³ ○ Dabo Yaya ⁴ ○ Detu Kersu ⁵ ○ Geta Bake ⁶ ○ Lilu Omoti ⁷ ○ Seka ⁸ ○ Setemma ⁹ ○ Wokito	KERSA ¹ ○ Adere Dika ² ○ Bala Wajo ³ ○ Bulbul ⁴ ○ Kusaye Beru ⁵ ○ Kara Gora ⁶ ○ Kellacha ⁷ ○ Serbo
CP19	Husband present for interview	¹ ○ Yes	⁰ ○ No	

Adapted from: Demographic and Health Surveys, JHPIEGO Birth preparedness/complication readiness tools for MNH & EQ-5D-3L Health Questionnaire Euro Qol Group 2009 (UK)

SECTION 1: [DEM] SOCIODEMOGRAPHIC INFORMATION

Good morning/afternoon. My name is _____. Thank you for taking the time to speak with me. I would like to start by asking you some general questions about yourself and your family.

DEM1a.	Do you know the year and month you were born in?	¹ ○ Yes	⁰ ○ No	SKIP TO DEM3
DEM1.	What year were you born in? <i>INTERVIEWER: Use the Calendar of events if needed. Record answers in Ethiopian calendar.</i>	Y Y Y Y		
DEM2.	What month were you born in? <i>INTERVIEWER: Record answers in Ethiopian calendar.</i>	M M SKIP TO DEM5 if complete ⁹⁹ ○ Do not know		
DEM3.	<i>If year of birth not known</i> What is your age?	years		
DEM5.	Have you ever attended school?	¹ ○ Yes	⁰ ○ No	SKIP TO DEM7
DEM6.	What is the highest level of education you have completed?	⁰ ○ None ⁶ ○ Grade 6 ¹² ○ Grade 12 ¹ ○ Grade 1 ⁷ ○ Grade 7 ¹³ ○ Higher ² ○ Grade 2 ⁸ ○ Grade 8 ⁸⁸ ○ Other (<i>specify</i>) ³ ○ Grade 3 ⁹ ○ Grade 9 ⁴ ○ Grade 4 ¹⁰ ○ Grade 10 ⁵ ○ Grade 5 ¹¹ ○ Grade 11		
DEM7.	Now I'd like you to read these four sentences to me. <i>INTERVIEWER Show literacy card in preferred language to respondent.</i> <i>Probe: Can you read any part of these sentences to me?</i>	⁰ ○ Cannot read at all ¹ ○ Able to read some parts of the sentences ² ○ Able to read all four sentences in full ³ ○ Visually impaired literate ⁴ ○ Visually impaired non-literate		

DEM8.	What work do you mainly do?	☐ Housewife ☐ Student ☐ Farmer ☐ Trader ☐ Government employee ☐ Private organization employee ☐ Domestic worker ☐ Daily labourer ☐ Other (specify)
DEM9.	Have you worked in the last 12 months?	☐ Yes ☐ No
DEM10.	What is your marital status?	☐ Never married ☐ Married ☐ Divorced ☐ Separated ☐ Widowed ☐ Other (specify)
INTERVIEWER: Ask questions about husband if NOT PRESENT to be interviewed (see response in CP19)		
DEM11 a	Do you know the year and month your husband was born in?	☐ Yes ☐ No SKIP TO DEM13
DEM11.	What year was your husband born in? <i>INTERVIEWER: Record answers in Ethiopian calendar.</i>	 Y Y Y Y
DEM12.	What month was your husband born in? <i>INTERVIEWER: Record answers in Ethiopian calendar.</i>	 M M ☐ Do not know
DEM13.	<i>If year of birth not known</i> How old is your husband?	years ☐ Do not know
DEM14.	What kind of work does your husband mainly do?	☐ Student ☐ Farmer ☐ Trader ☐ Government employee ☐ Private organization employee ☐ Domestic worker ☐ Daily labourer ☐ Other (specify)
DEM15.	Has your husband worked in the last 12 months?	☐ Yes ☐ No ☐ Do not know
DEM16.	Has your husband ever attended school ?	☐ Yes ☐ No SKIP TO DEM18 ☐ Do not know SKIP TO DEM18
DEM17.	What is the highest level of education your husband has completed?	☐ None ☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4 ☐ Grade 5 ☐ Grade 6 ☐ Grade 7 ☐ Grade 8 ☐ Grade 9 ☐ Grade 10 ☐ Grade 11 ☐ Grade 12 ☐ Higher ☐ Do not know ☐ Other (specify)

DEM18.	How many individuals are part of your household? <i>(i.e. usually stay together and have shared arrangements for eating, cooking and pool their money together)</i>	INTERVIEWER: DO NOT FORGET TO INCLUDE ALL CHILDREN
DEM19.	Of these, how many household members are adults (18 years or above)?	
DEM20.	How many of the adults in the household have jobs or are earning money through work or trade?	

SECTION 2: [IDM] INFORMATION SOURCES & HEALTH-RELATED DECISION MAKING

I would now like to ask you some questions about your sources of information and how decisions are made in your household.

IDM1.	How often do you read a newspaper or magazine - not at all, at least once a week or more than once a week?	⁰ ○ Not at all ¹ ○ At least once a week ² ○ More than once a week
IDM2.	How often do you listen to the radio - not at all, at least once a week or more than once a week?	⁰ ○ Not at all ¹ ○ At least once a week ² ○ More than once a week
IDM3.	How often do you watch television - not at all, at least once a week or more than once a week?	⁰ ○ Not at all ¹ ○ At least once a week ² ○ More than once a week
IDM4.	Do you own a mobile phone?	¹ ○ Yes ⁰ ○ No
IDM5.	Where do you usually get health information from? <i>Probe: Any other place?</i>	¹ ☐ Newspaper/Magazine ⁸⁸ ☐ Other (<i>Specify</i>) ² ☐ Radio ³ ☐ Television ⁴ ☐ Nurse/doctor ⁵ ☐ Health extension worker ⁶ ☐ Husband ⁷ ☐ Relative ⁸ ☐ Friends/neighbours ⁹ ☐ Traditional birth attendant ¹⁰ ☐ Health Development Army member
IDM6.	What were your main sources of advice/information about where to deliver your last child? <i>Probe: Any other place?</i>	¹ ☐ Newspaper/Magazine ⁸⁸ ☐ Other (<i>Specify</i>) ² ☐ Radio ³ ☐ Television ⁴ ☐ Nurse/doctor ⁵ ☐ Health extension worker ⁶ ☐ Husband ⁷ ☐ Relative

		⁸ ☐ Friends/neighbours ⁹ ☐ Traditional birth attendant ¹⁰ ☐ Health Development Army member
IDM7.	Has a health extension worker (HEW) ever visited your home?	¹ ☐ Yes ⁰ ☐ No SKIP TO IDM11
IDM8.	How often does the HEW visit your home?	⁰ ☐ Less than once a month ¹ ☐ 1-2 times a month ² ☐ 3-4 times a month (or every week) ³ ☐ 5 or more times a month
IDM9.	Does the HEW provide health information during her visits?	¹ ☐ Yes ⁰ ☐ No SKIP TO IDM11
IDM10.	What information does the HEW share with you during her visits to your home? <i><u>INTERVIEWER:</u> Do not read out. Select all that apply.</i> Probe: Anything else?	¹ ☐ Antenatal care at health facilities ² ☐ Care during pregnancy (diet, hygiene, rest, vaccinations, etc) ³ ☐ Danger signs during pregnancy ⁴ ☐ Birth/safe delivery planning ⁵ ☐ Danger signs during labour ⁶ ☐ Postpartum danger signs in mother ⁷ ☐ Danger signs in newborn ⁸ ☐ Newborn care – feeding, immunizations, cord care,etc ⁸⁸ ☐ Other (<i>Specify</i>)
IDM11.	Did the HEW visit you after you delivered your last child?	¹ ☐ Yes ⁰ ☐ No SKIP TO IDM13
IDM12.	How many times did the HEW visit you in the 6 weeks (42 days) after you had given birth to your last child? <i><u>INTERVIEWER:</u> Double check your numbers to ensure that they make sense.</i>	⁹⁹ ☐ Do not recall
IDM13.	In the last 12 months , have you or anyone in your family participated in or joined a programme that promotes antenatal care, delivery at health facilities or after birth care for mother and baby at health facilities?	¹ ☐ Yes ⁰ ☐ No SKIP TO IDM25

IDM24	What programs have you or your family participated in, in the last 12 months?	
IDM25	Have you been interviewed before for the IMCHA study like we are doing today? <i>INTERVIEWER: You can remind the participant what this study is about and that researchers from Jimma University and Ottawa University in Canada are conducting the study and visited the districts between October 2016 and January 2017.</i>	¹☐ Yes ⁰☐ No
IDM14.	Who usually decides how the money you earn will be used?	¹☐ Self ⁸⁸☐ Other (Specify) ²☐ Husband ³☐ Jointly with husband ⁴☐ Mother ⁵☐ Father ⁶☐ Mother-in-law ⁷☐ Father-in-law
IDM15.	<i>INTERVIEWER: Skip if woman not married.</i> Who usually decides how the money your husband earns will be used?	¹☐ Self ⁸⁸☐ Other (Specify) ²☐ Husband ³☐ Jointly with husband ⁴☐ Mother ⁵☐ Father ⁶☐ Mother-in-law ⁷☐ Father-in-law
IDM16.	Who usually makes decisions about health care for yourself ?	¹☐ Self ⁸⁸☐ Other (Specify) ²☐ Husband ³☐ Jointly with husband ⁴☐ Mother ⁵☐ Father ⁶☐ Mother-in-law ⁷☐ Father-in-law
IDM17.	Who usually makes decisions about health care for your children ?	¹☐ Self ⁸⁸☐ Other (Specify) ²☐ Husband ³☐ Jointly with husband ⁴☐ Mother ⁵☐ Father ⁶☐ Mother-in-law ⁷☐ Father-in-law

IDM18.	Who usually decides whether or not you will use family planning or birth spacing methods?	¹ ☐ Self ² ☐ Husband ³ ☐ Jointly with husband ⁴ ☐ Mother ⁵ ☐ Father ⁶ ☐ Mother-in-law ⁷ ☐ Father-in-law ⁸⁸ ☐ Other (<i>Specify</i>)
IDM19.	Who made the final decision about where you would give birth to your last child?	¹ ☐ Self ² ☐ Husband ³ ☐ Jointly with husband ⁴ ☐ Mother ⁵ ☐ Father ⁶ ☐ Mother-in-law ⁷ ☐ Father-in-law ⁸⁸ ☐ Other (<i>Specify</i>)
IDM20.	Who usually decides whether you can leave the house to visit family/friends, go out shopping, etc?	¹ ☐ Self ² ☐ Husband ³ ☐ Jointly with husband ⁴ ☐ Mother ⁵ ☐ Father ⁶ ☐ Mother-in-law ⁷ ☐ Father-in-law ⁸⁸ ☐ Other (<i>Specify</i>)
IDM21.	Are you a member of any social group, organization or association? For example, Women's Development Army, or iddir, etc?	¹ ☐ Yes ⁰ ☐ No SKIP TO REP1
IDM22.	What group are you a member of? INTERVIEWER: Select all that apply	¹ ☐ Farmers' group ² ☐ Women's group ³ ☐ Youth group ⁴ ☐ Kebele committee ⁵ ☐ Credit/savings group like <i>iddir, ekub</i> ⁶ ☐ Community Conversation ⁷ ☐ NGO-led group ⁸ ☐ Health Development Army ⁸⁸ ☐ Other (<i>Specify</i>)
IDM23.	Are you a leader of the women's health development army?	¹ ☐ Yes ⁰ ☐ No

SECTION 3: [REP] REPRODUCTIVE HISTORY OF INDEX WOMAN

I'd now like to ask you some questions about any pregnancies and births you have had during your life.

REP1.	How old were you when you first got married? INTERVIEWER: <i>If woman cannot remember, ask how long she has been married for and help her work out her age when she first got married.</i>	years

REP2.	How old were you when you first got pregnant?	years	
REP3.	How many times have you been pregnant during your life?		
REP6	How many livebirths have you ever had?		INTERVIEWER: Check against total pregnancies and other pregnancy outcomes
REP4	How many times in your life have you had an induced abortion ?		INTERVIEWER: Check against total pregnancies and other pregnancy outcomes
REP5	How many times in your life have you had a miscarriage ?		INTERVIEWER: Check against total pregnancies and other pregnancy outcomes
REP7	How many times in your life have you had a stillborn child ?		INTERVIEWER: Check against total pregnancies and other pregnancy outcomes
INTERVIEWER RESPONSE CHECK #1		Total pregnancies (REP3)	COPY FROM REP3
Do total pregnancies match total pregnancy outcomes? Enter totals in columns to double check responses in REP3-REP7		Total livebirths (REP6)	(1) COPY FROM REP6
		Total abortions (REP4)	(2) COPY FROM REP4
		Total miscarriages (REP5)	(3) COPY FROM REP5
		Total stillbirths (REP7)	(4) COPY FROM REP7
		Total pregnancy outcomes	(1+2+3+4)
		REP6check. Did the woman ever have twins?	¹ ○ Yes ⁰ ○ No
REP8	How many children have you delivered at home ?		
REP9	How many children have you delivered at a health centre or hospital ?		
REP10	How many children have you delivered en route (ex: on the road, in the ambulance)? <i>INTERVIEWER: This is the number of deliveries that did not occur at the respondent's home or at the health facility but elsewhere. For example: on the way to the health centre</i>		
INTERVIEWER RESPONSE CHECK #2		Total livebirths (REP6)	(1) COPY FROM REP6
Do total births match total delivery sites reported? <i>INTERVIEWER: Enter totals in columns to double check responses in REP8-REP10 against REP6-REP7</i>		Total stillbirths (REP7)	(2) COPY FROM REP7
		Total births	(1+2)
		Total home births (REP8)	(3) COPY FROM REP8

		Total facility births (REP9)	(4) COPY FROM REP9
		Total births en route (REP10)	(5) COPY FROM REP10
		Total delivery sites	(3+4+5)
REP14.	Did your last pregnancy result in a livebirth, stillbirth, miscarriage or abortion?	¹ ☐ Live birth – full term ² ☐ Live birth – preterm ³ ☐ Still birth	⁴ ☐ Miscarriage ⁵ ☐ Abortion
REP15.	Have you ever given birth to a premature baby (i.e gave birth to a live baby before completing 37 weeks of pregnancy)?	¹ ☐ Yes ⁰ ☐ No	
REP16.	Did you plan your last pregnancy?	¹ ☐ Yes ⁰ ☐ No	
REP17.	During your last pregnancy , did you experience any serious health problems related to the pregnancy?	¹ ☐ Yes ⁰ ☐ No SKIP TO REP22	
REP18.	What SERIOUS health problems did you experience during your last pregnancy? <i>Select all that apply</i>	¹ ☐ Bleeding ² ☐ Severe headache ³ ☐ Blurred vision ⁴ ☐ Convulsions/fits ⁵ ☐ Swollen face/hands ⁶ ☐ High fever ⁷ ☐ Loss of consciousness/fainting ⁸ ☐ Breathing difficulty ⁹ ☐ Severe weakness ¹⁰ ☐ Severe abdominal pain ¹¹ ☐ More/less fetal movement ¹² ☐ Water breaks without labour ¹³ ☐ Persistent vomiting ¹⁴ ☐ Infection ¹⁵ ☐ Mental health problems (ex: depression) ⁸⁸ ☐ Other(<i>Specify</i>)	
REP19.	Did you get help /seek assistance for the problem(s)?	¹ ☐ Yes ⁰ ☐ No SKIP TO REP21	
REP20.	ASK THIS QUESTION IF REP19=Yes Then GO TO REP22 Where did you get help from? <i>Select all that apply</i>	¹ ☐ Husband ² ☐ Family/relative ³ ☐ Friends/neighbours ⁴ ☐ Health extension worker ⁵ ☐ Doctor/nurse ⁸⁸ ☐ Other (<i>Specify</i>)	

		☐ Traditional birth attendant (TBA) ☐ Health Development Army
REP21.	ASK THIS QUESTION IF REP19=No Then GO TO REP22 What was the reason for not seeking assistance for the problem (s)? Select all that apply	☐ Didn't think it was necessary ☐ Husband/family didn't think it was necessary ☐ Facility too far ☐ No transport ☐ No childcare ☐ Too expensive ☐ Poor quality services ☐ Used home remedy ☐ Didn't know where to go ☐ Had no time ☐ Long wait times ☐ Inconvenient hours ☐ Felt better ☐ Health post usually closed ☐ Other (<i>Specify</i>)
REP22.	Did you suffer from any of these conditions during your last pregnancy? INTERVIEWER: Read out all the health conditions listed.	☐ No ☐ High blood pressure ☐ Diabetes ☐ HIV ☐ Malaria ☐ Other infection
REP23.	Have you experienced any health problems related to pregnancy during your other previous pregnancies?	☐ Yes ☐ No SKIP TO HSU1
REP24.	What health problems did you experience during your other previous pregnancies? INTERVIEWER: Select all that apply	☐ Bleeding ☐ Severe headache ☐ Blurred vision ☐ Convulsions/fits ☐ Swollen face/hands ☐ High fever ☐ Loss of consciousness/fainting ☐ Breathing difficulty ☐ Severe weakness ☐ Severe abdominal pain ☐ More/less fetal movement ☐ Water breaks without labour ☐ Persistent vomiting ☐ Infection ☐ Mental health problems (ex: depression) ☐ Other (<i>Specify</i>)

SECTION 4: [HSU] MATERNAL HEALTH CARE UTILIZATION

I would now like to ask you some questions about health services that you may have used during your last pregnancy, during your delivery of your last child and after delivery.

4.1 Antenatal care

HSU1.	Have you ever received antenatal care for any of your previous pregnancies ?	¹ ☐ Yes ⁰ ☐ No SKIP TO HSU3
HSU2.	Where did you usually receive antenatal care during your previous pregnancies? Select all that apply <i>INTERVIEWER: Select the place woman went most often for ANC care. Enter all sites mentioned in "Other" if it is not clear which site was used most often.</i>	¹ ☐ Health post ² ☐ Health centre ³ ☐ Maternity waiting home ⁴ ☐ Hospital ⁸⁸ ☐ Other (Specify)
HSU3.	Did you see anyone for antenatal care during your last pregnancy ?	¹ ☐ Yes SKIP TO HSU5 ⁰ ☐ No
HSU4.	SKIP TO HSU16 WHEN COMPLETE What was the reason for not getting antenatal care during your last pregnancy?	¹ ☐ Didn't think it was necessary ² ☐ Husband/family didn't think it was necessary ³ ☐ Facility too far ⁴ ☐ No transport ⁵ ☐ No childcare ⁶ ☐ Too expensive ⁷ ☐ Poor quality services ⁸ ☐ Used home remedy ⁹ ☐ Didn't know where to go ¹⁰ ☐ Had no time ¹¹ ☐ Long wait times ¹² ☐ Inconvenient hours ¹³ ☐ Felt better ¹⁴ ☐ Health post usually closed ⁸⁸ ☐ Other (Specify)
HSU5.	SKIP IF HSU3=NO How many times did you visit the health facility for antenatal care during your last pregnancy ?	⁰ ☐ Do not remember
HSU6.	SKIP IF HSU3=NO During your last pregnancy , how many months pregnant were you when you went for your FIRST antenatal care visit at the health facility?	months ⁰ ☐ Do not remember

HSU7.	SKIP IF HSU3=NO How many months pregnant were you when you LAST received antenatal care for your last pregnancy?	months ⁰○ Do not remember
HSU8.	SKIP IF HSU3=NO Where did you mainly receive antenatal care from during your last pregnancy? <i>INTERVIEWER: Select the place woman went most often for ANC care. Enter all sites mentioned in "Other" if it is not clear which site was used most often.</i>	¹ ○ Own home ⁸⁸○ Other (<i>Specify</i>) ² ○ Someone's home ³ ○ Government hospital ⁴ ○ Government health centre ⁵ ○ Government health post ⁶ ○ Private hospital ⁷ ○ Private clinic
HSU12.	SKIP IF HSU3=NO Did you receive counselling as part of the antenatal care visit during your last pregnancy?	¹ ○ Yes ⁰○ No SKIP TO HSU16 ⁹⁹○ Do not remember SKIP TO HSU16
HSU13.	SKIP IF HSU3=NO Can you tell me what information you were provided with during the counselling session? Do not prompt. Select all that apply	¹ ☐ Antenatal care at health facilities ⁹☐ Newborn care – feeding, immunizations ² ☐ Care during pregnancy (diet, hygiene, rest, vaccinations, etc) ⁸⁸☐ Other (<i>Specify</i>) ³ ☐ Danger signs during pregnancy ⁴ ☐ Birth/safe delivery planning ⁵ ☐ MWH services ⁶ ☐ Danger signs during labour ⁷ ☐ Postpartum danger signs in mother ⁸ ☐ Danger signs in newborn
HSU14.	SKIP IF HSU3=NO Did the health worker recommend where you should consider delivering your baby?	¹ ○ Yes ⁰○ No SKIP TO HSU16 ⁹⁸○ Do not remember SKIP TO HSU16
HSU15.	SKIP IF HSU3=NO Where did the health worker recommend you should deliver your baby?	¹ ○ Health post ⁸⁸○ Other (<i>Specify</i>) ² ○ Health centre ³ ○ Hospital ⁴ ○ Home ⁹⁸ ○ Do not remember

4.2 Intrapartum care

HSU16.	Where have you usually given birth to your children in the past? <i>INTERVIEWER: Select the place where most deliveries occurred. Enter all sites mentioned in "Other" if it is not clear which site was used most often.</i>	¹☐ Own home ⁸⁸☐ Other (<i>Specify</i>) ²☐ Someone else's home (ex: relative, TBA) ³☐ Government hospital ⁴☐ Government health centre ⁵☐ Government health post ⁶☐ Private hospital ⁷☐ Private clinic
HSU17.	SKIP TO WDK1 IF REP14=miscarriage or abortion Where did you give birth to your last child?	¹☐ Own home SKIP TO HSU19 ⁸⁸☐ Other (<i>Specify</i>) ²☐ Someone else's home (ex: relative, TBA) ³☐ Government hospital ⁴☐ Government health centre ⁵☐ Government health post ⁶☐ Private hospital ⁷☐ Private clinic
HSU18.	How did you reach the place where you gave birth to your last child?	¹☐ By foot ⁸⁸☐ Other (<i>Specify</i>) ²☐ By taxi ³☐ Bajaj (motorbike rickshaw) ⁴☐ Local stretcher ⁵☐ Ambulance ⁶☐ By horse/mule ⁷☐ By bicycle
HSU19.	SKIP TO HSU20 IF HSU17=hospital, health centre or clinic <i>INTERVIEWER: Ask only if respondent did NOT deliver at a health facility</i> What were the reasons why you did not give birth to your last child at a health facility? <i>Select all that apply</i>	¹☐ Didn't think it was necessary ²☐ Husband/family didn't think it was necessary ³☐ Facility too far ⁴☐ No transport ⁵☐ No childcare ⁶☐ Too expensive ⁷☐ Poor quality services ⁸☐ Unexpected/short labour ⁹☐ Didn't know where to go ¹⁰☐ Had no time ¹¹☐ No privacy ¹²☐ Inconvenient hours ¹³☐ Fear of procedures ¹⁴☐ Wanted family present ¹⁵☐ Not comfortable receiving services from male health care workers ¹⁶☐ Preferred birthing position not allowed at health facility ⁸⁸☐ Other (<i>Specify</i>)

HSU20.	Did you plan to give birth to your last child at this place?	¹ ☐ Yes	⁰ ☐ No
HSU21.	Prior to the delivery of your last child did you or your family make ANY arrangements for the birth of the child?	¹ ☐ Yes	⁰ ☐ No SKIP TO HSU47
HSU22.	What did you do? Did you..... <i>INTERVIEWER: Read out options and select all that apply</i>	¹ ☐ Save money for delivery? ² ☐ Organize transport to delivery location? ³ ☐ Identify skilled delivery attendant? ⁴ ☐ Get an MWH referral? ⁵ ☐ Identify blood donor? ⁶ ☐ Identify someone to look after your home? ⁷ ☐ Familiarize yourself with your estimated delivery date? ⁸ ☐ Identify a birth companion?	⁹ ☐ Identify a health facility to go to in case of emergency? ⁸⁸ ☐ Other (<i>Specify</i>)
HSU47	Prior to the delivery of your last child did you make a plan for an emergency or complication during pregnancy?	¹ ☐ Yes	⁰ ☐ No SKIP TO HSU23
HSU48	What did you do? Did you..... <i>INTERVIEWER: Read out options and select all that apply</i>	¹ ☐ Save money for an emergency? ² ☐ Identify someone to look after your home during the emergency? ³ ☐ Identify a health facility to go to in case of emergency? ⁴ ☐ Organize transport to a health facility in case emergency?	⁸⁸ ☐ Other (<i>Specify</i>)
HSU23.	Who assisted with the delivery of your last child? <i>INTERVIEWER: Do NOT prompt. Select all that apply</i>	¹ ☐ Husband ² ☐ Family/relatives ³ ☐ Friends/neighbours ⁴ ☐ Health extension worker ⁵ ☐ Doctor/nurse ⁶ ☐ Traditional birth attendant ⁷ ☐ Health Development Army member	⁸⁸ ☐ Other (<i>Specify</i>)

HSU24.	During the delivery of your last child , did you experience any serious health problems related to BIRTH?	☐ Yes ☐ No SKIP TO HSU26
HSU25.	What serious health problems did you experience during the DELIVERY of your LAST child? INTERVIEWER: Do NOT prompt. Select all that apply	☐ Bleeding ☐ Severe headache ☐ Blurred vision ☐ Convulsions/fits ☐ High fever ☐ Loss of consciousness/fainting ☐ Labour >12 hours ☐ Placenta not delivered 30min after delivery ☐ Don't know ☐ Other (<i>Specify</i>)
HSU26.	How was your last child delivered?	☐ Caesarean section (belly cut open and baby taken out) ☐ Forceps/vacuum extraction ☐ Vaginal delivery ☐ Other (<i>Specify</i>)

4.3 Postpartum care

FOR WOMEN WHO HAD A LIVEBIRTH OR STILLBIRTH

Now I'd like to ask you some questions about after you gave birth to your last child

HSU27	After you gave birth to your LAST child , did someone check on your health? <i>For example, someone examining you or asking you questions about your health?</i>	☐ Yes ☐ No SKIP TO HSU31
HSU28	How long after delivery did the first check take place?	minutes weeks hours months days ☐ Do not remember
HSU29	Who checked on your health at that time?	☐ Doctor ☐ Nurse/midwife ☐ TBA ☐ Relative/friend ☐ HEW ☐ Other (<i>Specify</i>)
HSU30	Where did this first check-up take place?	☐ Own home ☐ Someone else's home (ex: relative, TBA) ☐ Government hospital ☐ Government health centre ☐ Government health post ☐ Private hospital ☐ Private clinic ☐ Other (<i>Specify</i>)

HSU31	During the 6 weeks after the birth of your LAST baby, did you experience any serious health problems related to the birth?	¹ ☐ Yes ⁰ ☐ No SKIP TO HSU35
HSU32	What problems did you experience? INTERVIEWER: Do NOT prompt. Select all that apply.	¹ ☐ Bleeding ¹⁰ ☐ Foul smelling vaginal discharge ² ☐ Severe headache ¹¹ ☐ Inability to control urine/stool ³ ☐ Blurred vision ⁸⁸ ☐ Other (Specify) ⁴ ☐ Convulsions/fits ⁵ ☐ Swollen face/hands ⁶ ☐ High fever ⁷ ☐ Loss of consciousness/fainting ⁸ ☐ Breathing difficulty ⁹ ☐ Severe weakness
HSU33	Did you get help/seek assistance for the serious health problem(s) you experienced during the 6 weeks after the birth of your LAST child?	¹ ☐ Yes ⁰ ☐ No SKIP TO HSU35 if REP14=livebirth SKIP to HSU27B if REP14=abortion or miscarriage
HSU34	Where did you get help from? INTERVIEWER: Select all that apply	¹ ☐ Husband ⁷ ☐ Health Development Army ² ☐ Family/relative ⁸⁸ ☐ Other (Specify) ³ ☐ Friends/neighbours ⁴ ☐ Health extension worker ⁵ ☐ Doctor/nurse ⁶ ☐ Traditional birth attendant (TBA)

FOR WOMEN WHO HAD A LIVEBIRTH ONLY

HSU35	SKIP TO MWA1 IF REP14=miscarriage, abortion or stillbirth Did anyone check on your baby's health? For example, look at the cord to see if it was ok?	¹ ☐ Yes ⁰ ☐ No SKIP TO HSU40
HSU36	How long after delivery did the first check on your baby take place?	minutes weeks hours months days ☐ Do not remember

HSU37	Who checked on the baby's health at that time?	¹ ☐ Doctor ² ☐ Nurse/midwife ³ ☐ TBA ⁴ ☐ Relative/friend ⁵ ☐ HEW ⁸⁸ ☐ Other (<i>Specify</i>)
HSU38	Where did this first check on the baby's health take place?	¹ ☐ Own home ² ☐ Someone else's home (ex: relative, TBA) ³ ☐ Government hospital ⁴ ☐ Government health centre ⁵ ☐ Government health post ⁶ ☐ Private hospital ⁶ ☐ Private clinic ⁸⁸ ☐ Other (<i>Specify</i>)
HSU40	During the first 28 days after birth , did the baby experience any serious health problems ?	¹ ☐ Yes ⁰ ☐ No SKIP TO MWA1
HSU41	What serious health problems did the baby experience during the first 28 days after birth?	¹ ☐ Difficulty/fast breathing ² ☐ Yellow skin/eyes ³ ☐ Poor feeding ⁴ ☐ Pus/blood around cord ⁵ ☐ Very small baby ⁶ ☐ Lesions or blisters ⁷ ☐ Convulsions (fits) ⁸ ☐ Loss of consciousness/weak ⁹ ☐ Red/swollen eyes with pus ¹⁰ ☐ Cold to touch ¹¹ ☐ Vomiting/diarrhoea ¹² ☐ Fever ⁸⁸ ☐ Other(<i>Specify</i>)
HSU42	Did you get help/seek assistance for the baby's serious health problem(s)?	¹ ☐ Yes ⁰ ☐ No SKIP TO MWA1
HSU43	Where did you get help from for the baby's health problems? Select all that apply	¹ ☐ Husband ² ☐ Relative ³ ☐ Friends/neighbours ⁴ ☐ HEW ⁵ ☐ Doctor/Nurse ⁶ ☐ Traditional birth attendant ⁸⁸ ☐ Other (<i>Specify</i>)

FOR WOMEN WHO HAD A MISCARRIAGE OR ABORTION

Now I'd like to ask you some questions about the care you received after your last pregnancy ended

HSU27B	After your LAST pregnancy ended , did someone check on your health? <i>For example, someone examining you or asking you questions about your health?</i>	¹ ☐ Yes ⁰ ☐ No SKIP TO HSU31B
HSU28C	How long after the LAST pregnancy ended did the first check take place?	minutes weeks hours months days ⁰☐ Do not remember
HSU29	Who checked on your health at that time?	¹ ☐ Doctor ² ☐ Nurse/midwife ³ ☐ TBA ⁴ ☐ Relative/friend ⁵ ☐ HEW ⁸⁸ ☐ Other (<i>Specify</i>)
HSU30	Where did this first check-up take place?	¹ ☐ Own home ² ☐ Someone else's home (ex: relative, TBA) ³ ☐ Government hospital ⁴ ☐ Government health centre ⁵ ☐ Government health post ⁶ ☐ Private hospital ⁷ ☐ Private clinic ⁸⁸ ☐ Other (<i>Specify</i>)
HSU31B	During the 6 weeks after your LAST pregnancy ended, did you experience any serious health problems related to the pregnancy?	¹ ☐ Yes ⁰ ☐ No SKIP TO MWA1
HSU32B	What problems did you experience? <i><u>INTERVIEWER:</u> Do NOT prompt. Select all that apply.</i>	¹☐ Bleeding ²☐ Severe headache ³☐ Blurred vision ⁴☐ Convulsions/fits ⁵☐ Swollen face/hands ⁶☐ High fever ⁷☐ Loss of consciousness/fainting ⁸☐ Breathing difficulty ⁹☐ Severe weakness ¹⁰☐ Foul smelling vaginal discharge ¹¹☐ Inability to control urine/stool ⁸⁸☐ Other(<i>Specify</i>)

HSU33B	Did you get help/seek assistance for the serious health problem(s) you experienced during the 6 weeks after your LAST pregnancy ended?	¹ ☐ Yes ⁰☐ No SKIP TO MWA1
HSU34B	Where did you get help from? INTERVIEWER: Select all that apply	¹ ☐ Husband ⁷☐ Health Development Army ² ☐ Family/relative ⁸⁸☐ Other (Specify) ³ ☐ Friends/neighbours ⁴ ☐ Health extension worker ⁵ ☐ Doctor/nurse ⁶ ☐ Traditional birth attendant (TBA)

SECTION 5: [MWA] MATERNITY WAITING HOMES

I would like to now ask you some questions about maternity waiting homes

MWA1.	Have you heard of a maternity waiting home?	¹ ☐ Yes ⁰ ☐ No INTERVIEWER: Explain a maternity waiting home is a temporary place for pregnant women to stay close to the health centre before delivery for free if she lives far away or has health problems
MWA2.	Do you have a maternity waiting home in or near your kebele?	¹ ☐ Yes ⁰☐ No ⁹⁹☐ Do not know
MWA3.	What sort of services are offered/facilities available at maternity waiting homes? PROBE: Any other? Select all that apply	Facilities/amenities ⁸⁸☐ Other (Specify) ¹ ☐ Beds for sleeping ² ☐ Cooking facilities ³ ☐ Food and drinks ⁴ ☐ Toilet/latrine ⁵ ☐ Bathrooms ⁶ ☐ Electricity ⁷ ☐ Clean water Services ⁸ ☐ Check up by nurse/midwife ⁹ ☐ Visits by HEWs Other ⁹ ☐ Family visits allowed ¹⁰ ☐ Coffee ceremony

MWA20	What services and facilities do you think are important to be available to mothers who stay at maternity waiting homes?	Facilities/amenities ⁸⁸ ☐ Other (<i>Specify</i>) ¹ ☐ Beds for sleeping ² ☐ Cooking facilities ³ ☐ Food and drinks ⁴ ☐ Toilet/latrine ⁵ ☐ Bathrooms ⁶ ☐ Electricity ⁷ ☐ Clean water Services ⁸ ☐ Check up by nurse/midwife ⁹ ☐ Visits by HEWs Other ⁹ ☐ Family visits allowed ¹⁰ ☐ Coffee ceremony
MWA4.	What benefits do you think maternity waiting homes offer?	⁰ ☐ None ¹ ☐ Quick access to doctors/nurses ² ☐ Chance for mothers to rest ³ ☐ No need to organize emergency transport for delivery ⁹⁹ ☐ Do not know ⁸⁸ ☐ Other (<i>Specify</i>)
MWA5.	Do you know of anyone in your family/neighbourhood who has used a maternity waiting home?	¹ ☐ Yes ⁰☐ No
MWA6.	Have you ever visited someone at a maternity waiting home?	¹ ☐ Yes ⁰☐ No
MWA7.	Have you ever used a maternity waiting home yourself?	¹ ☐ Yes SKIP TO MWH18 ⁰☐ No
MWA17.	What are the reasons for never having used a maternity waiting home?	¹ ☐ Did not know about maternity waiting homes ² ☐ Do not see any benefit of staying at maternity waiting homes ³ ☐ Was not sure when to go to the maternity waiting home / was not sure of delivery date ⁴ ☐ Did not plan for delivery ⁵ ☐ Did not want to give birth at the health centre ⁶ ☐ Live close to health facility where I can deliver

		☐ Too costly to get to maternity waiting homes ☐ Poor services – no food, etc ☐ Have no childcare ☐ Husband/family did not want me to stay there ☐ Did not get a referral ☐ Have heard of negative experiences from women who have stayed there before ☐ There was no one to take me to the maternity waiting home ☐ I did not have family/friends available to look after me at the maternity waiting home ☐ Inadequate sleeping arrangements ex: no blankets ☐ Health centre staff do not look after women/ check on them ☐ No toilets ☐ No bathrooms/bathing areas ☐ Inadequate lighting / no power sources ☐ Family is not allowed to stay with me ☐ No food served or adequate kitchen facilities ☐ No clean water available ☐ No entertainment/activities available ☐ Did not have a positive experience during previous stay ☐ Other (<i>Specify</i>)
MWA18.	Did you use a maternity waiting home during your last pregnancy ?	☐ Yes SKIP TO MWA8 ☐ No
MWA19.	What were the reasons for not using a maternity waiting home during your last pregnancy? <i><u>INTERVIEWER:</u> Do NOT read out. Select all that apply.</i>	☐ Did not know about maternity waiting homes ☐ Do not see any benefit of staying at maternity waiting homes ☐ Was not sure when to go to the maternity waiting home / was not sure of delivery date ☐ Did not plan for delivery ☐ Did not want to give birth at the health centre ☐ Live close to health facility where I can deliver ☐ Too costly to get to maternity waiting homes ☐ Poor services – no food, etc ☐ Have no childcare ☐ Husband/family did not want me to stay there ☐ Did not get a referral

		¹² ☐ Have heard of negative experiences from women who have stayed there before ¹³ ☐ There was no one to take me to the maternity waiting home ¹⁴ ☐ I did not have family/friends available to look after me at the maternity waiting home ¹⁵ ☐ Inadequate sleeping arrangements ex: no blankets ¹⁶ ☐ Health centre staff do not look after women/ check on them ¹⁷ ☐ No toilets ¹⁸ ☐ No bathrooms/bathing areas ¹⁹ ☐ Inadequate lighting / no power sources ²⁰ ☐ Family is not allowed to stay with me ²¹ ☐ No food served or adequate kitchen facilities ²² ☐ No clean water available ²³ ☐ No entertainment/activities available ²⁴ ☐ Did not have a positive experience during previous stay ⁸⁸ ☐ Other (<i>Specify</i>)
MWA8.	Were you referred to the maternity waiting home by a HEW or other health worker?	¹ ☐ Yes ⁰ ☐ No
MWA9.	SKIP TO MWA15 IF MWA18=No Why did you decide to go to the maternity waiting home? <i><u>INTERVIEWER:</u> Do NOT read out. Select all that apply.</i>	¹ ☐ Referred by HEW ² ☐ Used MWH during previous pregnancy ³ ☐ Live far away from facility ⁴ ☐ Expecting complications during delivery ⁵ ☐ Not satisfied with TBA/ want to deliver at health facility ⁶ ☐ Needed rest ⁷ ☐ Husband/family wanted me to ⁸⁸ ☐ Other (<i>Specify</i>)

MWA10.	SKIP TO MWA15 IF MWA18=No How close to your delivery date were you when you went to the maternity waiting home? <i>INTERVIEWER: Explain to woman that you need to know how much time was left before she gave birth.</i>	days weeks
MWA11.	SKIP TO MWA15 IF MWA18=No How long did you stay at the maternity waiting home before delivery?	days weeks
MWA12.	SKIP TO MWA15 IF MWA18=No How long did you stay at the maternity waiting home after delivery?	days weeks
MWA13.	SKIP TO MWA15 IF MWA18=No What services were available to you during your stay at the maternity waiting home? <i>INTERVIEWER: Do NOT read out. Select all that apply.</i>	Facilities/amenities ¹☐ Beds for sleeping ²☐ Cooking facilities ³☐ Food and drinks ⁴☐ Toilet/latrine ⁵☐ Bathrooms ⁶☐ Electricity ⁷☐ Clean water Services ⁸☐ Check up by nurse/midwife ⁹☐ Visits by HEWs Other ¹⁰☐ Family visits allowed ¹¹☐ Coffee ceremony ⁸⁸☐ Other (<i>Specify</i>)
MWA15	Would you recommend using a maternity waiting home to your pregnant family and/or friends?	¹☐ Yes SKIP TO WDK1 ⁰☐ No
MWA16	Why would you NOT recommend the use of a maternity waiting home to your pregnant family members or friends?	¹☐ Culturally appropriate to deliver at home ²☐ MWHs are expensive ³☐ No privacy/confidentiality at MWHs ⁴☐ TBAs are closer than MWHs ⁴☐ Poor services/inadequate supplies ⁸⁸☐ Other (<i>Specify</i>)

SECTION 6: [WDK] DANGER SIGN KNOWLEDGE & PERCEPTIONS

I would now like to ask you some questions about pregnancy and childbirth in general.

WDK1.	Can women experience serious, unexpected health problems during pregnancy?	¹ ☐ Yes	⁰ ☐ No SKIP TO WDK5	⁹⁹ ☐ Do not know SKIP TO WDK5
WDK2.	What are some of the serious health problems that can occur during pregnancy? <i>INTERVIEWER: Do NOT prompt. Select all mentioned.</i>	¹ ☐ Bleeding ² ☐ Severe headache ³ ☐ Blurred vision ⁴ ☐ Convulsions/fits ⁵ ☐ Swollen face/hands ⁶ ☐ High fever ⁷ ☐ Loss of consciousness/fainting ⁸ ☐ Breathing difficulty ⁹ ☐ Severe weakness ¹⁰ ☐ Severe abdominal pain ¹¹ ☐ More/less fetal movement ¹² ☐ Water breaks without labour ¹³ ☐ Persistent vomiting ¹⁴ ☐ Infection	¹⁵ ☐ Mental health problems (ex: depression) ⁸⁸ ☐ Other (<i>Specify</i>)	
WDK3.	In your opinion could a pregnant woman die from this problem/any of these problems?	¹ ☐ Yes	⁰ ☐ No	⁹⁹ ☐ Do not know
WDK4.	In your opinion could a pregnant woman lose the baby from this problem/any of these problems?	¹ ☐ Yes	⁰ ☐ No	⁹⁹ ☐ Do not know
WDK5.	Can a woman experience serious health problems during labour/childbirth ?	¹ ☐ Yes	⁰ ☐ No SKIP TO WDK9	⁹⁹ ☐ Do not know SKIP TO WDK9
WDK6.	What are some of the serious health problems that can occur during labour/childbirth? <i>INTERVIEWER: Do NOT prompt. Select all mentioned.</i>	¹ ☐ Bleeding ² ☐ Severe headache ³ ☐ Blurred vision ⁴ ☐ Convulsions/fits ⁵ ☐ High fever ⁶ ☐ Loss of consciousness/fainting ⁷ ☐ Labour > 12 hours	⁸ ☐ Placenta not delivered 30min after birth ⁹⁹ ☐ Do not know ⁸⁸ ☐ Other (<i>Specify</i>)	
WDK7.	In your opinion could a woman die from this problem/any of these problems?	¹ ☐ Yes	⁰ ☐ No	⁹⁹ ☐ Do not know

WDK8.	In your opinion could a woman lose her baby from this problem/any of these problems?	¹ ○ Yes ⁰ ○ No ⁹⁹ ○ Do not know
WDK9.	Can a woman experience serious health problems during the first 6 weeks after delivery ?	¹ ○ Yes ⁰ ○ No SKIP TO WDK12 ⁹⁹ ○ Do not know SKIP TO WDK12
WDK10.	What are some of the serious health problems that can occur in the mother during the first 6 weeks after delivery ? <i>INTERVIEWER: Do NOT prompt. Select all mentioned.</i>	¹ ☐ Severe bleeding ⁸⁸ ☐ Other(<i>Specify</i>) ² ☐ Severe headache ³ ☐ Blurred vision ⁴ ☐ Convulsions ⁵ ☐ Swollen face/hands ⁶ ☐ High fever ⁷ ☐ Loss of consciousness ⁸ ☐ Breathing difficulty ⁹ ☐ Severe weakness ¹⁰ ☐ Foul smelling vaginal discharge ¹¹ ☐ Inability to control urine/stool
WDK11.	In your opinion could a woman die from this problem/any of these problems?	¹ ○ Yes ⁰ ○ No ⁹⁹ ○ Do not know
WDK12.	Can a baby experience serious health problems during the first 28 days of life/after birth ?	¹ ○ Yes ⁰ ○ No SKIP TO ATT1 ⁹⁹ ○ Do not know SKIP TO ATT1
WDK13.	What are some of the serious health problems that can occur in the baby during the first 28 days of life/after birth ? <i>INTERVIEWER: Do NOT prompt. Select all mentioned.</i>	¹ ☐ Difficulty/fast breathing ⁹ ☐ Red/swollen eyes with pus ² ☐ Yellow skin/eyes ¹⁰ ☐ Cold to touch ³ ☐ Poor feeding ¹¹ ☐ Vomiting/diarrhoea ⁴ ☐ Pus/blood around cord ¹² ☐ Fever ⁵ ☐ Very small baby ⁸⁸ ☐ Other(<i>Specify</i>) ⁶ ☐ Lesions or blisters ⁷ ☐ Convulsions (fits) ⁸ ☐ Loss of consciousness/weak
WDK14.	In your opinion could a baby die from this problem/any of these problems?	¹ ○ Yes ⁰ ○ No ⁹⁹ ○ Do not know

SECTION 7: [ATT] ATTITUDES TOWARDS MATERNAL CARE SERVICES

Now I am going to read out a list of common opinions about pregnancy, delivery and the period after childbirth. Please tell me if you agree, disagree or neither agree nor disagree with these statements. There is no right or wrong answer. We are only interested in hearing your opinion about the situation in your kebele.

ATT1.	A woman should plan ahead of time where she will give birth to her baby	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT2.	Antenatal care visits at the health facility are necessary for healthy pregnant women	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT3.	It is not necessary for a husband to accompany his wife to antenatal care visits	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT4.	Women who are healthy are not at risk for complications during delivery	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT5.	When women do not go to a health facility to give birth it is often because it is too expensive	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT6.	When women do not go to a health facility to give birth it is often because it is too difficult to get there	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT7.	When women do not go to a health facility to give birth it is often because the staff do not treat women respectfully	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT8.	It is not necessary for a husband to accompany his wife to the health facility when she is giving birth.	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT9.	When women do not go to a health facility to give birth it is often because they are afraid of receiving unwanted procedures	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT10.	When women do not go to a health facility to give birth it is often because it is unacceptable to be attended by male health workers	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT11.	Once a woman has had experience delivering a baby, she does not need to go to a health facility to deliver any of her future babies	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT12.	A woman who has complications during delivery/labour has a better chance of survival if doctors/nurses/midwives are present	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT13.	A newborn is most vulnerable to death and illness between birth and 28 days after birth	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree
ATT14.	It is important for mothers who have recently given birth to visit a health facility with their newborn for a check up	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree

ATT15.	It is important to get babies vaccinated at the health facility to protect them against common illnesses and possible death	¹ ○ Agree	² ○ Neither agree nor disagree	³ ○ Disagree

SECTION 8: [PHF] PERCEPTIONS OF HEALTH FACILITIES

I would now like to ask you some questions about places where women give birth and receive care during pregnancy

PHF1.	Can you tell me where a woman can go to give birth to a baby with the assistance from a doctor/nurse/midwife? <i>INTERVIEWER: Do NOT prompt. Select all mentioned.</i>	¹ ☐ Hospital ² ☐ Health centre ³ ☐ Health post ⁴ ☐ Maternity waiting home ⁸⁸ ☐ Other (<i>Specify</i>)	
PHF2.	Do women have to pay to receive services related to pregnancy and delivery at this place?	¹ ○ Yes ⁰ ○ No SKIP PHF4 ⁹⁹ ○ Do not know SKIP PHF4	
PHF3.	Would you say the amount to be paid is expensive, reasonable, or cheap?	¹ ○ Expensive ² ○ Reasonable ³ ○ Cheap	
PHF4.	Is there a health facility in or near your kebele?	¹ ○ Yes ⁰ ○ No SKIP TO PHF10 ⁹⁹ ○ Do not know SKIP TO PHF10	
PHF5.	What type of a health facility is it? <i>INTERVIEWER: Read out answer options if necessary</i>	¹ ○ Health post ² ○ Health centre ³ ○ Government Hospital ⁵ ○ Private hospital ⁴ ○ Private clinic ⁸⁸ ○ Other (<i>Specify</i>)	
PHF6.	How would you usually get there? <i>PROBE: What type of transport would you mainly use?</i>	¹ ○ By foot ² ○ By taxi ³ ○ Bajaj (motorbike rickshaw) ⁴ ○ Local stretcher ⁵ ○ Ambulance ⁶ ○ Horse/mule ⁷ ○ Bicycle ⁸⁸ ○ Other (<i>Specify</i>)	
PHF7.	How long does it take to get to this facility from your home using this method of transport?	minutes hours ⁰ ○ Do not remember	
PHF8	In your opinion, how would you rate the services offered at the health facility in/near your kebele? Would you say they are very good, good, fair, poor or very poor?	¹ ○ Very good ² ○ Good ³ ○ Fair ⁴ ○ Poor ⁵ ○ Very poor	

PHF9	Can you tell me what is/are the reason(s) that you feel that way about this health facility?	¹ ☐ Doctor/nurse always there ² ☐ Facility always open ³ ☐ Respectful staff ⁴ ☐ Short waiting times ⁵ ☐ Competent staff ⁵ ☐ Patient privacy maintained ⁸⁸ ☐ Other (<i>Specify</i>)	⁶ ☐ Doctor/nurse never there ⁷ ☐ Facility often closed ⁸ ☐ Disrespectful staff ⁹ ☐ Long waiting times ¹⁰ ☐ Incompetent staff ¹¹ ☐ Patient privacy not maintained ⁸⁹ ☐ Other (<i>Specify</i>)

ONLY FOR WOMEN WHO GAVE BIRTH TO THEIR LAST CHILD AT A HEALTH FACILITY (SEE HSU17)

PHF10	What health facility did you deliver your LAST child at?	<table border="0"> <tr> <td>GOMMA</td> <td>SEKA CHEKORSA</td> <td>KERSA</td> </tr> <tr> <td>¹☐ Beshasha</td> <td>¹☐ Bake Gudo</td> <td>¹☐ Adere Dika</td> </tr> <tr> <td>²☐ Chami Chago</td> <td>²☐ Buyo</td> <td>²☐ Bala Wajo</td> </tr> <tr> <td>³☐ Choche</td> <td>Kechema</td> <td>³☐ Bulbul</td> </tr> <tr> <td>⁴☐ Dhayi</td> <td>³☐ Dabo Yaya</td> <td>⁴☐ Kusaye Beru</td> </tr> <tr> <td>Kechene</td> <td>⁴☐ Detu Kersu</td> <td>⁵☐ Kara Gora</td> </tr> <tr> <td>⁵☐ Gembe</td> <td>⁵☐ Geta Bake</td> <td>⁶☐ Kellacha</td> </tr> <tr> <td>⁶☐ Kedemasa</td> <td>⁶☐ Lilu Omoti</td> <td>⁷☐ Serbo</td> </tr> <tr> <td>⁷☐ Limu Shayi</td> <td>⁷☐ Seka</td> <td>⁸⁸☐ Other</td> </tr> <tr> <td>⁸☐ Meti Koticha</td> <td>⁸☐ Setemma</td> <td>(<i>Specify</i>)</td> </tr> <tr> <td>⁹☐ Omo Gurude</td> <td>⁹☐ Wokito</td> <td></td> </tr> <tr> <td>¹⁰☐ Yachi</td> <td>⁸⁸☐ Other</td> <td></td> </tr> <tr> <td>⁸⁸☐ Other</td> <td>(<i>Specify</i>)</td> <td></td> </tr> </table>	GOMMA	SEKA CHEKORSA	KERSA	¹ ☐ Beshasha	¹ ☐ Bake Gudo	¹ ☐ Adere Dika	² ☐ Chami Chago	² ☐ Buyo	² ☐ Bala Wajo	³ ☐ Choche	Kechema	³ ☐ Bulbul	⁴ ☐ Dhayi	³ ☐ Dabo Yaya	⁴ ☐ Kusaye Beru	Kechene	⁴ ☐ Detu Kersu	⁵ ☐ Kara Gora	⁵ ☐ Gembe	⁵ ☐ Geta Bake	⁶ ☐ Kellacha	⁶ ☐ Kedemasa	⁶ ☐ Lilu Omoti	⁷ ☐ Serbo	⁷ ☐ Limu Shayi	⁷ ☐ Seka	⁸⁸ ☐ Other	⁸ ☐ Meti Koticha	⁸ ☐ Setemma	(<i>Specify</i>)	⁹ ☐ Omo Gurude	⁹ ☐ Wokito		¹⁰ ☐ Yachi	⁸⁸ ☐ Other		⁸⁸ ☐ Other	(<i>Specify</i>)	
GOMMA	SEKA CHEKORSA	KERSA																																							
¹ ☐ Beshasha	¹ ☐ Bake Gudo	¹ ☐ Adere Dika																																							
² ☐ Chami Chago	² ☐ Buyo	² ☐ Bala Wajo																																							
³ ☐ Choche	Kechema	³ ☐ Bulbul																																							
⁴ ☐ Dhayi	³ ☐ Dabo Yaya	⁴ ☐ Kusaye Beru																																							
Kechene	⁴ ☐ Detu Kersu	⁵ ☐ Kara Gora																																							
⁵ ☐ Gembe	⁵ ☐ Geta Bake	⁶ ☐ Kellacha																																							
⁶ ☐ Kedemasa	⁶ ☐ Lilu Omoti	⁷ ☐ Serbo																																							
⁷ ☐ Limu Shayi	⁷ ☐ Seka	⁸⁸ ☐ Other																																							
⁸ ☐ Meti Koticha	⁸ ☐ Setemma	(<i>Specify</i>)																																							
⁹ ☐ Omo Gurude	⁹ ☐ Wokito																																								
¹⁰ ☐ Yachi	⁸⁸ ☐ Other																																								
⁸⁸ ☐ Other	(<i>Specify</i>)																																								
PHF11	How did you get to this facility?	¹ ☐ By foot ² ☐ By taxi ³ ☐ Bajaj (motorbike rickshaw) ⁴ ☐ Local stretcher ⁵ ☐ Ambulance ⁶ ☐ Horse/mule ⁷ ☐ Bicycle ⁸⁸ ☐ Other (<i>Specify</i>)																																							
PHF12	How long does it take to get to this facility from your home using this method of transport?	minutes hours																																							
PHF13	In your opinion, how would you rate the services offered at this health facility? Would you say they are very good, good, fair, poor or very poor?	¹ ☐ Very good ² ☐ Good ³ ☐ Fair ⁴ ☐ Poor ⁵ ☐ Very poor																																							

PHF14	Can you tell me what is/are the reason(s) that you feel that way about this health facility? Do NOT read out. Select all that apply.	¹ ☐ Doctor/nurse always there ² ☐ Facility always open ³ ☐ Respectful staff ⁴ ☐ Short waiting times ⁵ ☐ Competent staff ⁵ ☐ Patient privacy maintained ⁸⁸ ☐ Other (Specify)	⁶ ☐ Doctor/nurse never there ⁷ ☐ Facility often closed ⁸ ☐ Disrespectful staff ⁹ ☐ Long waiting times ¹⁰ ☐ Incompetent staff ¹¹ ☐ Patient privacy not maintained ⁸⁹ ☐ Other (Specify)

SECTION 9: [QOL] HEALTH-RELATED QUALITY OF LIFE ASSESSMENT

I would like to now ask you a few questions about your health-related quality of life. I will read out a statement that describes some a situation that might be affecting your quality of life, please tell me the extent to which this is true.

QOL1.	Problems in walking about	¹ ☐ No problem ² ☐ Some problems ³ ☐ Confined to bed
QOL2.	Problems washing or dressing yourself	¹ ☐ No problem ² ☐ Some problems ³ ☐ Unable to do
QOL3.	Problems doing usual activities like housework, farming, etc	¹ ☐ No problem ² ☐ Some problems ³ ☐ Unable to do
QOL4.	Feel pain or discomfort	¹ ☐ No pain/discomfort ² ☐ Moderate pain/discomfort ³ ☐ Extreme pain/discomfort
QOL5.	Feel anxious or depressed	¹ ☐ No anxiety/depression ² ☐ Moderate anxiety/depression ³ ☐ Extreme anxiety/depression
QOL6.	On a scale from 0 to 10, where 10 is the best health you can imagine and 0 is the worst health you can imagine, could you please tell me how good or bad your health is TODAY.	

SECTION 10: [SS] SOCIAL SUPPORT

I would like to ask some questions about social support that you received during pregnancy, during delivery and after delivery.

SS1.	During your LAST pregnancy was there someone that you could depend on when you were in need?	¹ ☐ Yes ⁰ ☐ No SKIP TO SS3
SS2.	What was the relationship of this person/these people to you?	¹ ☐ Husband ² ☐ Parents ³ ☐ Siblings ⁶ ☐ Religious group ⁷ ☐ Community group ⁸ ☐ Health worker

	Do NOT read out. Select all that apply.	☐ Friends/Neighbours ☐ In-laws ☐ Health extension worker ☐ Other (<i>Specify</i>)
SS3.	For your LAST child, did you receive any practical help from anyone? <i>Example: help with child care, house chores, cattle herding, etc</i>	☐ Yes ☐ No SKIP TO SS6
SS4.	When did you receive this help? Select all that apply	☐ During pregnancy ☐ during delivery period ☐ after delivery
SS5.	From whom did you receive this help?	☐ Husband ☐ Parents ☐ Siblings ☐ Friends/Neighbours ☐ In-laws ☐ Religious group ☐ Community group ☐ Health worker ☐ Health extension worker ☐ Other (<i>Specify</i>)
SS16	How close is your relationship with the people that you received the assistance from?	☐ Not strong ☐ Strong ☐ Very strong ☐ Do not know
SS17	How satisfied were you with the support/help you received?	☐ Not satisfied ☐ Satisfied ☐ Very satisfied ☐ Do not know
SS6.	For your LAST child, was there anyone who accompanied you to the health facility and provided personal assistance to you? <i>Example: helped you bathe, stayed with you at the health facility, escorted you to the latrine at night, etc</i>	☐ Yes ☐ No SKIP TO SS9
SS7.	When did you receive this help? Select all that apply	☐ During pregnancy ☐ during delivery period ☐ after delivery
SS8.	What was the relationship of the person/people you received this assistance from?	☐ Husband ☐ Parents ☐ Siblings ☐ Friends/Neighbours ☐ In-laws ☐ Religious group ☐ Community group ☐ Health worker ☐ Health extension worker ☐ Other (<i>Specify</i>)

SS18	How close is your relationship with the people that you received the assistance from?	⁰ ☐ Not strong ¹ ☐ Strong	² ☐ Very strong ⁹⁹ ☐ Do not know
SS19	How satisfied were you with the support/help you received?	⁰ ☐ Not satisfied ¹ ☐ Satisfied	² ☐ Very satisfied ⁹⁹ ☐ Do not know
SS9.	For your LAST child, was there anyone who provided you with emotional support ? <i>Example: someone who you could talk to when you were upset or worried, provided you with encouragement and reassurance</i>	¹ ☐ Yes	⁰ ☐ No SKIP TO SS12
SS10.	When did you receive this help? Select all that apply	¹ ☐ During pregnancy	² ☐ during delivery period ³ ☐ after delivery
SS11.	What was the relationship of the person/people you received this assistance from?	¹ ☐ Husband ² ☐ Parents ³ ☐ Siblings ⁴ ☐ Friends/Neighbours ⁵ ☐ In-laws ⁶ ☐ Religious group ⁷ ☐ Community group ⁸ ☐ Health worker ⁹ ☐ Health extension worker	⁸⁸ ☐ Other (<i>Specify</i>)
SS20	How close is your relationship with the people that you received the assistance from?	⁰ ☐ Not strong ¹ ☐ Strong	² ☐ Very strong ⁹⁹ ☐ Do not know
SS21	How satisfied were you with the support/help you received?	⁰ ☐ Not satisfied ¹ ☐ Satisfied	² ☐ Very satisfied ⁹⁹ ☐ Do not know
SS12.	For your last child, did you receive any financial or in-kind assistance from anyone? <i>For example: received money/loans, medicines, clothes, food, etc</i>	¹ ☐ Yes	⁰ ☐ No SKIP TO SS15
SS13.	What did you receive? Select all that apply	¹ ☐ Money ² ☐ Food ³ ☐ Clothes ⁴ ☐ Medicine ⁵ ☐ Cooking fuel ⁶ ☐ Furniture	⁸⁸ ☐ Other (<i>Specify</i>)
SS14.	When did you receive this help? Select all that apply	¹ ☐ During pregnancy	² ☐ during delivery period ³ ☐ after delivery

SS15.	What was the relationship of the person/people you received this assistance from?	¹ ☐ Husband ² ☐ Parents ³ ☐ Siblings ⁴ ☐ Friends/Neighbours ⁵ ☐ In-laws ⁶ ☐ Religious group ⁷ ☐ Community group ⁸ ☐ Health worker ⁹ ☐ Health extension worker ⁸⁸ ☐ Other (<i>Specify</i>)
SS22	How close is your relationship with the people that you received the assistance from?	⁰ ☐ Not strong ¹ ☐ Strong ² ☐ Very strong ⁹⁹ ☐ Do not know
SS23	How satisfied were you with the support/help you received?	⁰ ☐ Not satisfied ¹ ☐ Satisfied ² ☐ Very satisfied ⁹⁹ ☐ Do not know

SECTION 11: [DEM] SOCIODEMOGRAPHIC INFORMATION continued

Thank you. We are now going to end with some final questions on your household.

DEM21.	Do you own this or any other house either alone or jointly with someone else?	⁰ ☐ No ¹ ☐ Alone only ² ☐ Jointly
DEM22.	Does any member of this household own any agricultural land ? <i>Ex: land where you grow coffee, teff, maize, etc</i>	¹ ☐ Yes ⁰ ☐ No ⁹⁹ ☐ Do not know
DEM24	Does any member of this household own any non-agricultural land ? <i>Ex: land where cattle graze, etc</i>	¹ ☐ Yes ⁰ ☐ No ⁹⁹ ☐ Do not know
DEM26	What is the main source of drinking water for members of your household?	¹ ☐ Piped into dwelling ² ☐ Piped into yard/plot ³ ☐ Public tap/standpipe ⁴ ☐ Borehole ⁵ ☐ Protected well ⁶ ☐ Unprotected well ⁷ ☐ Protected spring ⁸ ☐ Unprotected spring ⁹ ☐ Rainwater ⁸⁸ ☐ Other (<i>Specify</i>)
DEM29	What kind of toilet facility do members of your household usually use?	⁰ ☐ No facility/use bush ¹ ☐ Flush to piped sewer ² ☐ Flush to septic tank ³ ☐ Flush to pit latrine ⁴ ☐ Flush, don't know ⁵ ☐ Ventilated improved pit latrine ⁶ ☐ Pit latrine with slab ⁷ ☐ Open pit ⁸⁸ ☐ Other (<i>Specify</i>)
DEM30	What type of fuel does your household mainly use for cooking ?	¹ ☐ Electricity ² ☐ Natural gas ³ ☐ Kerosene ⁴ ☐ Charcoal ⁵ ☐ Wood ⁸⁸ ☐ Other (<i>Specify</i>)

DEM32	How many rooms in this household are used for sleeping ?																	
DEM34	Does this household own any livestock/farm animals or poultry?	¹ ☐ Yes ⁰ ☐ No SKIP TO DEM36																
DEM35	How many of the following animals does the household own?	<table border="0"> <tr> <td>^a☐ Milk cows</td><td> </td></tr> <tr> <td>^b☐ Bulls/ox</td><td> </td></tr> <tr> <td>^c☐ Horses/donkeys/mules</td><td> </td></tr> <tr> <td>^d☐ Goats</td><td> </td></tr> <tr> <td>^e☐ Sheep</td><td> </td></tr> <tr> <td>^f☐ Chicken/poultry</td><td> </td></tr> <tr> <td>^g☐ Other (<i>Specify</i>)</td><td> </td></tr> <tr> <td>^g☐ Other (<i>Specify</i>)</td><td> </td></tr> </table>	^a ☐ Milk cows		^b ☐ Bulls/ox		^c ☐ Horses/donkeys/mules		^d ☐ Goats		^e ☐ Sheep		^f ☐ Chicken/poultry		^g ☐ Other (<i>Specify</i>)		^g ☐ Other (<i>Specify</i>)	
^a ☐ Milk cows																		
^b ☐ Bulls/ox																		
^c ☐ Horses/donkeys/mules																		
^d ☐ Goats																		
^e ☐ Sheep																		
^f ☐ Chicken/poultry																		
^g ☐ Other (<i>Specify</i>)																		
^g ☐ Other (<i>Specify</i>)																		
DEM36	Does your household have any of the following?	<table border="0"> <tr> <td>^a☐ Electricity.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^b☐ Radio.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^c☐ Television.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^d☐ Refrigerator.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^e☐ Car/truck.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^f☐ Bicycle.....</td><td>¹☐ Yes ⁰☐ No</td></tr> <tr> <td>^g☐ Motorcycle.....</td><td>¹☐ Yes ⁰☐ No</td></tr> </table>	^a ☐ Electricity.....	¹ ☐ Yes ⁰ ☐ No	^b ☐ Radio.....	¹ ☐ Yes ⁰ ☐ No	^c ☐ Television.....	¹ ☐ Yes ⁰ ☐ No	^d ☐ Refrigerator.....	¹ ☐ Yes ⁰ ☐ No	^e ☐ Car/truck.....	¹ ☐ Yes ⁰ ☐ No	^f ☐ Bicycle.....	¹ ☐ Yes ⁰ ☐ No	^g ☐ Motorcycle.....	¹ ☐ Yes ⁰ ☐ No		
^a ☐ Electricity.....	¹ ☐ Yes ⁰ ☐ No																	
^b ☐ Radio.....	¹ ☐ Yes ⁰ ☐ No																	
^c ☐ Television.....	¹ ☐ Yes ⁰ ☐ No																	
^d ☐ Refrigerator.....	¹ ☐ Yes ⁰ ☐ No																	
^e ☐ Car/truck.....	¹ ☐ Yes ⁰ ☐ No																	
^f ☐ Bicycle.....	¹ ☐ Yes ⁰ ☐ No																	
^g ☐ Motorcycle.....	¹ ☐ Yes ⁰ ☐ No																	
DEM38A	Do you know how much the total income for your household was last year? <i>INTERVIEWER: Assist women to provide a rough estimate of household income i.e income earned by all adult household members from formal and informal sources</i>	¹ ☐ Yes ⁰ ☐ No																
DEM38	Last year, what was the total income for your household for the year?	Birr ⁹⁹ ☐ Do not know																
DEM46	Do you have health insurance?	¹ ☐ Yes ⁰ ☐ No																
DEM47	What type of health insurance is it? Prompt if necessary	¹ ☐ Government ⁸⁸ ☐ Other(<i>Specify</i>) ² ☐ Private																
DEM48	INTERVIEWER: Observe and record Main material of the floor of the dwelling	<table border="0"> <tr> <td>¹☐ Earth/sand</td><td>⁶☐ Bricks</td></tr> <tr> <td>²☐ Dung</td><td>⁸⁸☐ Other (<i>Specify</i>)</td></tr> <tr> <td>³☐ Wood planks</td><td></td></tr> <tr> <td>⁴☐ Polished wood</td><td></td></tr> <tr> <td>⁵☐ Cement</td><td></td></tr> </table>	¹ ☐ Earth/sand	⁶ ☐ Bricks	² ☐ Dung	⁸⁸ ☐ Other (<i>Specify</i>)	³ ☐ Wood planks		⁴ ☐ Polished wood		⁵ ☐ Cement							
¹ ☐ Earth/sand	⁶ ☐ Bricks																	
² ☐ Dung	⁸⁸ ☐ Other (<i>Specify</i>)																	
³ ☐ Wood planks																		
⁴ ☐ Polished wood																		
⁵ ☐ Cement																		
DEM49	INTERVIEWER: Observe and record Main material of the roof of the dwelling	<table border="0"> <tr> <td>¹☐ Thatch</td><td>⁴☐ Cement</td></tr> <tr> <td>²☐ Corrugated iron</td><td>⁸⁸☐ Other (<i>Specify</i>)</td></tr> <tr> <td>³☐ Wood</td><td></td></tr> </table>	¹ ☐ Thatch	⁴ ☐ Cement	² ☐ Corrugated iron	⁸⁸ ☐ Other (<i>Specify</i>)	³ ☐ Wood											
¹ ☐ Thatch	⁴ ☐ Cement																	
² ☐ Corrugated iron	⁸⁸ ☐ Other (<i>Specify</i>)																	
³ ☐ Wood																		

DEM50	INTERVIEWER: Observe and record Main material of the exterior walls of the dwelling	☐ Mud with wood ☐ Other (<i>Specify</i>) ☐ Stone with mud ☐ Wood ☐ Cement ☐ Bricks

Thank you for taking the time to share this information with us.

Chapter 8. Discussion

The overall objectives of my thesis were to contribute to the understanding of the factors that influence the use of maternal healthcare services in low-resource settings; and to evaluate how well-functioning MWHs operating in enabling environments could contribute to increased service use in rural Ethiopia. A central theme throughout my work has been the importance of context in determining access to care. I began by exploring this in two main ways; firstly, I used the social ecological model to select potential explanatory factors that reflected dimensions of women's household, community and health system environments. Secondly, I used spatial analyses to investigate the effects of heterogeneity between localities on women's utilization of services. I then evaluated how effective two intervention components addressing geographical and social contextual barriers were in improving women's use of delivery care and other maternal healthcare services.

In this final chapter, I integrate these findings and position them in the existing body of evidence. I reflect on the lessons learned from the trial and make suggestions for future work.

8.1. Having social and financial resources favours maternity waiting home use

In Chapter 4, I reported significant associations of several factors with MWH use, including availability of companion support, household wealth, physical separation from health facilities and women's occupation. Several studies have described the crucial roles that companions play in supporting women's stay at MWHs (1–3) and navigating the health system in general.(4) These companions are indispensable to women when it comes to organizing food and water in poorly equipped MWHs which are common in Ethiopia (2,3) and elsewhere.(1,5,6) Companions in Ethiopia are often women's husbands (3,7) and their presence is indicative of the financial and logistic support they have provided to enable women to use MWHs. A recent study conducted in the Southern, Nations, Nationalities and People's (SNNP) region, adjacent to Oromia region, reported an increased odds of MWH use among women who had someone to assist with childcare;(8) qualitative work from Sierra Leone also found that family support with childcare facilitated women's using of waiting facilities.(5) These findings highlight the importance of the various dimensions of social support in facilitating MWH use depending on the specific context within which women live.

In our study, the odds of MWH use increased with higher levels of household wealth. This is unsurprising as women from wealthier households are probably better able to absorb the indirect costs associated with MWH stay; these costs, related to transport, food and companion accommodation, represent important barriers to MWH use in Ethiopia (2,9) and other developing countries.(10–15) In fact, out-of-pocket expenses associated with facility deliveries have been shown to be high for MWH

users in Ethiopia; in the SNNP region, for instance, non-medical costs and losses in productivity were higher among MWH users than non-users regardless of duration of MWH stay.⁽¹⁶⁾ As it is, delivering at a health facility is an expensive undertaking for rural families in low resource countries. One study described expenses related to health centre births amounted to almost a third of the monthly household income of poorest families.⁽¹⁷⁾ Costs have also been found to rise steadily with increasing distance, further intensifying the economic burden on women in remote areas who are likely the prime beneficiaries of MWH stay.⁽¹⁶⁾ While high transport costs did not emerge as a principal reason for non-use in our trial (Appendix A7.2.1.3), these women were not asked about the impact of other costs connected to MWH stay, which may still be a financial liability for families.

Women's participation in healthcare decisions was also not found to be significantly associated with MWH use in our study setting. This may be partly because the majority of women in our study, similar to another conducted in Amhara region ⁽¹⁸⁾, were actively involved in such decision-making. Interesting interactions have also been uncovered when decision-making is considered together with overall community support for delivery care use. The influence of women's involvement in decision making was lower in communities perceived to be highly supportive of delivery care; living in such areas was associated with increased odds of service use regardless of whether women were included in the decision-making process. The strong policy emphasis on facility deliveries in our setting may exert a similar effect, reducing the relevance of women's decision-making autonomy on MWH use. It is also possible that when decisions specifically about MWH use are considered, women's involvement is slightly more important. This was the case when women's intended use of MWHs was investigated in Amhara¹⁽¹⁸⁾ and SNNP regions.⁽⁸⁾ However, the latter also reported higher odds of MWH use among women whose husbands did not approve of MWH stay ⁽⁸⁾ despite indications from qualitative work that unsupportive husbands who do not approve of MWH stay can make use difficult for women.^(12,14,19) These contradictory findings may in part be due to methodological issues.² HEWs

¹ This was an interesting study that also considered perceived social pressure to use MWHs, women's own attitude towards MWHs as well as how feasible they thought MWH use was. However, scores were generated from rating responses to a series of questions and an arbitrary cut-off of 60% was used to categorize responses and create binary variables. Two main issues arose from this approach: firstly, women who provided neutral answers to several questions were counted as positive (ex: neither agreeing nor disagreeing with the benefits of MWH stay and anticipated positive experiences were counted as having a favourable attitude towards MWH stay). Secondly, the combination of several factors, that likely exert different and independent effects, into one score (ex: awareness about danger signs, awareness of MWH services, awareness of expected delivery date, importance of birth preparedness, etc) makes it difficult to disentangle associations and understand what potentially modifiable factors are important and which are not.

² p-value based selection methods were relied upon to select 13 variables out of the 25 hypothesized to affect MWH use for the multivariable regression model, increasing the chances that important explanatory factors were left out. The association estimates of only six variables were reported. The presence of multicollinearity was also possible since there were several variables that were likely correlated and may partially explain the unintuitive shifts in direction of estimates. Temporal issues with the women's attitude variable were also possible; cross-sectional data collection meant it was difficult to determine whether women's attitudes towards MWHs affected use or vice versa. The failure to account for clustering in data as a result of multistage sampling may also have meant that the already wide confidence intervals were even wider making it difficult to judge which factors actually had statistically significant associations with MWH use. The absence of information about how the sampling frame was obtained or constructed and how complete it was coupled with the relatively high reported levels of

and health workers may also have a role to play; another study in SNNP region reported higher odds of MWH use among women when these groups were relied upon to make decisions about health facility visits in general³.(20)

Returning to our study findings, when physical separation was considered in terms of estimated travel time between homes and health facilities, women living more than 30 minutes away were found to have a higher odds of MWH use. However, when distances were evaluated, distinct patterns emerged. Women living between one to two kilometres from health centres had a higher, but non-significant odds of use MWHs than those less than a kilometre away, but residing more than five kilometres away significantly reduced the odds of use (Appendix 4.2). Part of the reason for this seems to be related to MWH awareness; while overall awareness about the availability of MWH services stood at 56% at baseline, awareness levels gradually decreased with increasing distances (Appendices 7.2.1.1 and 7.2.1.3). Concerns about the lack of amenities and monitoring by midwives also seems to have played a role in discouraging MWH use among women (Appendix 7.2.1.3). The considerable effort and expense to reach the MWH is likely weighed up against anticipated benefits, which diminish when poor accommodation and neglect by midwives is expected by women.(10,21,22) Securing and paying for transport may also be more difficult the further women live from the MWH.(3,11) While women acknowledge that MWH stay has the advantage of timely access to care should complications arise, it frequently does not eliminate the challenges around cost and availability of transport that make it difficult for many women to deliver at health facilities.(3,5,13)

The absence of a significant association between MWH stay and community levels of delivery care use may partly relate to the strong emphasis on institutional births in the country; this policy focus has led to a gradual shift in social norms favouring facility deliveries over home births (23) independent of MWH use. Distance may also be a contributing factor as the need for, and awareness of, MWHs changes depending on how far away homes are located. About 30% of the study population lived within two kilometres of health centres (Appendix 7.2.3.3) which may have dampened the correlation between MWH use and community delivery care use norms. Large distances, however, remained a barrier to delivery care use as there were clear differences in home births between women living close to health centres compared to those living at a distance (Appendix 7.2.3.2). This is not surprising as women who

MWH use (43%) made it difficult to determine how likely the presence of selection bias was and how representative the sample was.

³ It is important to note that the authors used causal diagrams to estimate direct effects. Direct effects are components of the total effect between a variable of interest and the outcome which do not include contributions from intermediate variables; they are also adjusted for all possible confounders.(145) The authors, however, included very few potential confounders making estimates highly susceptible to confounding and possibly inaccurate estimates of direct effects. The decision-maker variable (which only had three response options which included the woman herself, HEWs or health workers) only appeared to be adjusted for complications during pregnancy and distance.(20)

live far away are also more likely to be further from road networks and less accessible by ambulance and other motorized forms of transport. Indeed, over a third of women who did not use delivery care services and lived more than two kilometres away from the health centre reported lack of transport as one of the problems. There is also the possibility that an aggregation of individual responses (i.e., percent of women who gave birth at a health facility in the PHCU) did not adequately capture place effects that result in some communities being more willing and able to use delivery care services than others. These “compositional” variables may fail to describe “features that are not reducible to the characteristics of the group.”(24)

This was one of the first studies in Ethiopia, to the best of my knowledge, to identify a potential gap in terms of the way MWHs are being promoted to the community. Although this needs to be investigated further, the large proportion of short term stays at MWHs and the lack of consideration of MWHs as part of birth preparedness planning points to a need to discuss MWHs as alternatives to emergency transport with families. HEWs in Ethiopia represent an important medium through which this can be conveyed as they are accessible to families and trusted sources of information.(25)

8.2. Context matters: local diversity in factors influencing maternal healthcare service use

When relationships between potential explanatory factors and service outcomes were assumed to be constant across the entire study area, several of the associations identified were consistent with other studies in similar settings. For instance, higher levels of household wealth found to be important for ANC and delivery care use in our study has been previously reported to be significant factor.(26–28) This could lead to conclusion that access to financial resources yields similar results across all localities. However, when the magnitude of association and relevance of each explanatory factor was examined locally a number of interesting trends emerged that I reported in Chapter 6.

Firstly, factors assumed to exhibit uniform statistically significant associations regardless of locality were not found to be relevant everywhere. Using household wealth to illustrate this, strong associations with ANC use were detected in a few *kebeles* but local estimates were not statistically significant across the rest of the study area. Similar variation was also seen with danger sign awareness which also showed very localized correlations with all three services. While this does not mean that creating awareness among women about danger signs would be inconsequential, it does suggest that further investment of resources such as creating additional education materials around danger signs, or focusing on them at pregnant women’s conferences, for instance, may not yield the desired increases in services use as other factors may be more influential.

A second feature exposed by localised analyses was that factors found not to be statistically significant using global models exhibited significant associations in certain areas. For instance, parity was not significant using conventional statistical models; but local analyses unmasked a corridor of *kebeles* in the eastern part of the study area running from Gembe PHCU to Geta Bake PHCU where higher parity was associated with a higher odds of delivery care use. Studies from Ethiopia considering global estimates have generally found higher parity or birth order to have an inverse association with delivery care use.(29–33) However, these studies run the risk of concealing local variation by considering estimates averaged across the entire country (29,31,33) or several districts.(30,32) Similarly, global associations between women's involvement in healthcare decision making and ANC use were not statistically significant, but local analysis indicated it was an important factor for several *kebeles* in Kersa district. Contextual diversity in study settings, focusing on different parts of Ethiopia, may partially explain why some studies have reported significant associations (see Wado et al.(34) for example) and others have not (see Dutamo et al.(35) for example) in addition to obscuring local variation when national estimates are generated (see Tiruneh et al.(36) for example).

Patterns, however, change depending on the service under consideration. When it came to delivery care use, women's involvement in decision-making was neither significant at the global nor local level. Similar results were obtained when a nationally representative dataset from Ethiopia was analysed and several other decision-making domains considered.(36) High involvement in decision-making and the zero home births policy environment discussed in section 8.1 may be contributing factors. In areas where there is strong push towards facility deliveries, undesirable practices such as family shaming (2) and fining(11) to discourage birthing outside the facility setting have also been described. It is not surprising, then, that whether or not women are involved in decisions about delivery site is a moot point. Additionally, the transition towards more service use could be as a result of the shift in decision making dynamics. Younger women feel better informed, less influenced by older generations (who may be more resistant to facility-based care) and better supported by husbands who may still have the ultimate say.(23)

Prior contact with maternal healthcare services was strongly associated with most recent service use when associations were estimated across the entire study area as other studies have found.(28,37–39) This was also the only explanatory variable which also exhibited strong associations, albeit varying, across many localities (Chapter 7). This underlines the importance of the health system establishing and maintaining connections with women. However, recent literature on retention of women across the continuum of maternal healthcare in Ethiopia has brought to light the enormity of losses between antenatal and postnatal care. Fairly low percentages of Ethiopian women (ranging from just 7% to 12%) have been found to use all three essential maternal healthcare services.(40–42) In addition to regional variability in the magnitude of losses, lower household wealth and large distances were reported to be

highly correlated with the deficits observed between ANC and delivery care use.(42) In Oromia region, a staggering 91% of women who reported having at least four ANC contacts during their most recent pregnancy had no PNC contacts.(42)

While contextual differences are frequently referred to when discussing healthcare access, they are not often addressed in analyses beyond rural-urban stratification (26–28,37,39,43) or the inclusion of aggregated individual responses to “control” for context.(31,44–46) These reductionist approaches attempt to distil contextual effects and fail to capture the complexity of place effects that are a consequence of the physical structure, social and material capital and historical power relations of a space.(47) Ignoring differences at local levels by only considering averaged estimates at higher spatial scales also diminishes the primacy of women’s lived experiences which differ depending on the local contexts where they are born, live, work and seek healthcare. As Freedman and Schaaf assert, “change will happen when we.....deeply interrogate what shapes women’s actual experiences of health services”.(48)

Decentralized governance in Ethiopia has resulted in the gradual transfer of responsibility of healthcare delivery to sub-national levels such as regions and *woredas*. The emphasis on the role that sub-national state entities have to play in the delivery of public goods is a result of the realization that complex issues cannot be dealt with solely by national governments.(49) Indeed, the World Health Organization advocates for involvement of sub-national structures in planning due to “positive impacts on accountability, increased community participation and better mitigation of geographical and social imbalances.”(50) Decentralized approaches, however, have the potential to widen or shrink existing inequities in healthcare depending on how funds are allocated and how well policy decisions reflect local needs.(51) Sub-national policymakers require access to evidence relevant to their constituencies in order to avoid “making poor policy inferences” that can result from using data pooled across regions.(52) In addition to inadequate financial and human resources, sub-national policymakers have described lack of relevant data as a barrier to evidence-based planning.(53) In Uganda, for example, district health managers found that using district-specific evidence helped them create more practical annual work plans using a more systematic approach to planning.(54)

8.3. Effect of functional maternity waiting homes and leader training on delivery care use in rural Ethiopia

8.3.1. Trial results compared to available evidence on MWHs and service uptake

The results of the trial reported in Chapter 7 suggest that when MWHs⁺ were combined with local leader training workshops, they did not result in significant improvements in utilization of delivery care, ANC or PNC services. Being among the first randomized trials in the world to evaluate the effect

of MWHs on maternal healthcare service uptake, there are no comparable results available as yet. A quasi-experimental study⁴ evaluating differences in institutional births between improved MWHs and comparison sites in Zambia was completed in December 2018 (55), but the results have not yet been published⁵. Results from the study's baseline, cross-sectional household survey, however, indicated that use of existing MWHs was associated with higher odds of having four or more ANC contacts (adjusted OR 1.43, 95% CI: 1.25 to 1.65) and four PNC contacts (adjusted OR 1.99, 95% CI: 1.30 to 3.07).⁽⁵⁶⁾

Several key differences exist between the Zambian and Ethiopian settings, highlighting how contextual differences and heterogeneity in MWH models could potentially influence outcomes. Firstly, the MWHs evaluated by the Zambia group were located in districts that had an on-going health system strengthening project.⁽⁵⁶⁾ Known as Saving Mothers, Giving Life (SMGL), the initiative was funded by several United States government partners and included a host of interventions including raising community awareness about pregnancy complications, upgrading health facilities and equipping them with staff and commodities, improving links between the community and health facilities through transportation systems as well as construction of MWHs.⁽⁵⁷⁾ The baseline assessments coincided with the “scale-up and scale-out” phase of the SMGL project.⁽⁵⁸⁾

Secondly, utilization of MWHs at baseline was much higher in these Zambian districts (32%)⁽⁵⁶⁾ than in our study area where it ranged between 6% to 7%. Participants in the Zambian trial were also targeted from villages located at least 9.5 kilometres from the health facilities with MWHs, thus focusing on a different population base. The Zambian study population also tended to have relatively higher access to resources than women in our setting judging by the larger proportion of women who owned mobile phones in 2016 (~7% our setting (Appendix 7.2.3.7) versus ~60% Zambia).^(4,59) Trial sites also differed between the two studies; while our study focused exclusively on MWHs attached to government health centres offering basic emergency obstetric care, the Zambia trial also included MWHs at referral hospitals, some of which were mission run and better resourced.^(60,61)

Finally, while there are some similarities in the roles played by HEWs in Ethiopia and the Safe Motherhood Action Group (SMAG)⁶ volunteers in Zambia, SMAGs vigorously promote MWH use

⁴ Of the 40 randomly selected health facility clusters included in the Zambian study, 20 facilities were randomly allocated to receive the Core MWH intervention or to usual care. Among the remaining 20 facilities, 10 were identified as intervention sites by the Ministry of Health where implementing partners constructed upgraded MWHs as the high volume of projects and research activities in the region created community fatigue and reduced the acceptability of randomization. The two sets of 20 facilities are managed by different implementing partners and are located in different districts/provinces in Zambia.⁽⁶⁰⁾

⁵ Last search performed on 2nd December 2020 prior to finalization of dissertation write-up.

⁶ The SMAG concept was developed by the United Nations Population Fund in 2002 (62) and was gradually scaled-up throughout Zambia by external partners. SMAGs include male and female community health volunteers and traditional birth attendants who receive a five-day training on topics related to making motherhood safer such as how to identify danger signs, the importance of birth preparedness planning, encouraging use of antenatal, delivery and postnatal care services, etc. Their

(62), often accompany women to health facilities for birth and even assist pregnant women with domestic duties.(63) Their continued presence, described as “instrumental [to] the success of MWHs”, however, is uncertain as funding for SMAGs was reported to be dwindling close to project termination.(11) This underscores the need to clearly distinguish between implementation under “routine conditions” and that which is supplemented with additional resources and supports that are central to successful intervention function. Under circumstances where external funding is provided and researchers play a role in supporting intervention delivery, plans for sustaining these inputs are required for the interventions to be useful.(64)

8.3.2. *Impact of implementation challenges on the trial findings*

Two unexpected circumstances compromised the delivery of our interventions as planned. Firstly, lists of pregnant women that are routinely maintained by HEWs and that were identified as a suitable sampling frame at the project conception phase were found to be incomplete and outdated at study initiation a year later. This required re-directing project funds to conduct a listing exercise to update HEW registers. One of the consequences of this was a delay in the commencement of baseline data collection, which in turn reduced the overall duration of intervention delivery.

Secondly, underlying political tensions intensified during the study period resulting in a state of emergency being declared twice during that time.(65) The uncertainty, restricted movement, and disruptions to communication systems caused further delays in data collection and distribution of supplies to intervention MWHs. It also delayed the start of the leader training workshops. The general levels of apprehension, particularly in Oromia region (66) where the project was based, meant that leaders experienced difficulties in organizing activities and families were less able to attend them. Proximity to conflict (67) and other crises (68) has, not surprisingly, been reported to impact access to and utilization of maternal healthcare services.

Ancillary analyses conducted (Chapter 7) were helpful in beginning to explore in what ways the shortened duration and disrupted delivery may have diminished intervention effectiveness. If interventions had been successfully implemented, higher awareness about MWH services and benefits, elevated referral levels and more MWH use would have been expected in the combined intervention than other trial arms at endline. Women in both intervention arms would also have been expected to cite local leaders as sources of health information and practical support as a result of their engagement with the community to improve access to maternal healthcare services including MWHs. In general, however, no differences between trial arms were found in any of these indicators. A smaller percentage

responsibilities include referring women to health facilities for care, follow up women who are referred and encouraging spousal involvement.(63,146)

of women were aware of MWH services at endline than baseline and awareness levels progressively decreased as distance between homes and MWHs increased. This might be a sign that awareness was a result of proximity rather than active promotion by providers, which also meant that highest awareness was among women who were least likely to need MWHs.

The fact that neither members of the Development Army nor religious leaders were found to be key health information sources for women was suggestive of a lack of greater engagement by providers in the intervention arm compared than those in the usual care arm. This hypothesis was somewhat corroborated by a lack of difference between trial arms in MWH referrals by midwives and home visits by HEWs. HEW turnover noted during the study period (69) may also have further compromised engagement levels. ANC contacts may also have been missed opportunities to discuss MWH stay as none of the women interviewed at endline recall MWH services being mentioned. All this may have partly been consequences of interference with planned activities caused by political strain and an insufficient period over which the interventions were delivered. Deficiencies in the quality of services received by users in the combined intervention arm could also have discouraged MWH use by other women in this arm.

Variation in local contexts may have further diminished intervention effects as women in some localities experienced an overlap in barriers associated with both facility deliveries and MWH stay more acutely than others. The prohibitive effect of distance, for instance, may have been slightly mitigated by higher levels of wealth in Gomma district PHCUs. PHCUs varied significantly in their levels of MWH use with many registering very low use. Several of these PHCUs had high levels of home births and women citing a lack of transport and large distances as deterrents to service use indicating geographical inaccessibility was a barrier to health facility access. Lilu Omoti, a PHCU randomized to the combined intervention arm and located in Seka Chekorsa district, provides an interesting illustrative example of how local context could influence intervention effectiveness. The potential for MWHs to benefit women was present in this PHCU with almost 70% of women reporting home births (Appendix 7.2.3.2) and close to 40% of these women attributing this to transport challenges (Appendix 7.2.3.4). MWHs, however, remained barely used (Appendix 7.2.3.1) and no women reported integrating MWHs into their birth preparedness planning (Appendix 7.2.2.2). Spatial analyses revealed that Lilu Omoti also had a relatively small proportion of wealthiest households (Chapter 5) implying that few women had the financial resources needed to use MWHs. However, the availability of companion support was strongly associated with delivery care use (Chapter 6). About one-fifth of women in Lilu Omoti belonged to community groups such as *Iddirs* and close to 40% received practical support from friends and neighbours (Appendices 7.2.3.5). This may have partially alleviated the inhibitory effects of poverty and distance on delivery care access in this PHCU resulting in at least some women using delivery care services.

8.4. Are maternity waiting homes operating in an enabling environment an effective strategy to improve maternal healthcare service use?

The evidence from our trial cannot provide a direct answer to this question because intervention delivery was compromised by implementation issues described above. However, the study did provide insight in several key areas which contribute to the existing body of evidence on MWHs and may be important considerations for future work.

8.4.1. Integration of MWHs into routine promotion of strategies to increase delivery care use

The assimilation of MWHs into routine promotion of delivery care use may not yet have reached optimal levels. Hardly any trial participants mentioned securing a referral to an MWH as part of their birth preparedness and complication readiness planning. It is possible that while families may have been aware of the existence of MWHs and their potential to provide some women with easy access to skilled providers, they did not view them as solutions for their own situations. The social and financial resources required for their use and the persisting challenge of securing transport to and from MWHs may both have outweighed the benefits of MWH stay for families. The compartmentalized approach used to sensitize families about MWHs may also be contributing to the discrepancy between familiarity with MWHs and actual use. Awareness creation activities in the intervention arms appeared to focus on subjects such as care during pregnancy, danger signs and the importance of delivering at a health facility.⁽⁶⁹⁾ When they did include a discussion about planning for birth, the mention of MWH stay was not common.⁽⁶⁹⁾ This was seen when topics covered during ANC visits were examined and mention of MWH stay was visibly absent (Appendix 7.2.1.6). Information about MWHs is also not included in the existing Health Extension Program training manual⁷.⁽⁷⁰⁾

Advice to families to call an ambulance for labouring women (or have HEWs do so) as a strategy to promote facility deliveries in this setting is quite common (23,69) possibly at the expense of planning for MWH use. While the availability of emergency transport is a critical component of health services, ambulances are generally procured to address emergencies and provide essential pre-health facility care. In rural Ethiopia, a few ambulances are typically shared by health facilities in a district (71–74). A national survey conducted in 2016 reported the ratio of public ambulances to population as 1:80,000 in Oromia region; nationally, the majority of functional ambulances were located at hospital level with only 12% of health centres having a dedicated, functioning ambulance.⁽⁷⁵⁾ Despite this, there appears to be a growing expectation that ambulances will be available to any women who go into labour who

⁷Discussions with policy implementers in the Jimma Zone Health Office as well as questions put to national level policy makers from the Ministry of Health attending the National Advisory Committee annual meetings between 2015 and 2019 corroborated the lack of both MWH-specific materials and the comprehensive inclusion of MWHs in health promotional resources in Ethiopia.

cannot access transport themselves (73,76,77) that is encouraged by frontline workers.(23,69,78–80) This potential mismatch between community expectations and the current formal structure of emergency transport may be partly fuelling community disappointment with the health system and possibly contributing to delays for a growing number of women. However, more research is needed to understand how families, community health providers and healthcare workers in this setting conceptualize obstetric emergencies. Additionally, the implications for equitable access to care of a dedicated transportation system for pregnant women and new mothers needs to be considered in the absence of widespread road networks and access to mobile phones in Ethiopia.

8.4.2. *Bringing “home” to maternity waiting homes*

There is on-going debate about excessive medicalization of birth versus the safety of non-hospitalized deliveries.(81,82) In high-income countries, concerns about high levels of medical intervention and costs to the health system of managing uncomplicated births among low risk women in specialized settings (83) have led to the consideration of alternative options. For low-income countries, however, emphasis is placed on getting all women to deliver at health facilities, with recent calls to shift this entirely to tertiary care institutions.(84) From the perspective of the healthcare community, the labour and postpartum periods represent dangerous times making it necessary for all women to deliver at health facilities in the presence of skilled health workers.(85) This may be particularly important in developing countries such as Ethiopia where road networks and reliable emergency transport systems are not widespread enough to make it safe for women to deliver at alternative venues. While most women agree that skilled attendants are crucial for managing complications, giving birth is not viewed as a process that always requires attention from medical practitioners.(86,87) In fact, a qualitative study investigating rural Ethiopian women’s perspectives on birth, described a normal delivery to be one that was “short, easy and at home”.(88) All women express the desire for “safe, supportive, kind, respectful and responsive care”.(89) This is often more attainable at home than at health facilities where poor quality and disrespectful care have been widely documented in low resource settings (90–95) including Ethiopia.(96–98) However, women’s preferences for supportive home environments, where they are more in control, are sometimes interpreted as unmodern (99) or simply reflecting a lack of understanding of the importance of skilled care.(100)

MWHs may be uniquely positioned to reconcile the divergence in views about the best place to give birth to a baby in Ethiopia, particularly if they are coupled with respectful maternity care at the health facility to which they are attached. The national guidelines on MWHs underscore the importance of “creating a home-like environment” to encourage women to consider their use.(101) The value placed

on this feature is evident in the inclusion of the *buna* (coffee) ceremony⁸, a ritual that is an integral part of Ethiopian daily life, as one of the eleven indicators of MWH functionality. Our MWH intervention component included the purchase of supplies to recreate the comforts of home ranging from bedding to items required for the *buna* ceremony and preparation of traditional *injera* bread to accompany meals.

Future MWH interventions may extend this sense of home by accommodating women's desires to have family around them (14,15,72) through the design of companion spaces. Where companions spaces have been reported to be available, they are generally temporary structures of poor quality.(61,102) Even a custom-built MWH in Malawi that received high satisfaction ratings on several features fell short when it came to companion accommodation as this had not been purpose-built but evolved out of need.(103) The challenge lies in balancing women's need for privacy (11,14) with the presence of family. Explicit consideration of companion accommodation is also crucial in light of the enabling role that companions may have in MWH use (Chapter 4) as well as in positive birth experiences.(104) Moreover, the emphasis on more active participation of husbands in maternal healthcare (82,104,105) requires targeted efforts to make services more husband friendly(106) to enable couples that arrive together to be accommodated appropriately. Limited space at MWHs often means that pregnant women are prioritized and companions not permitted to stay with them.(3,15) This is particularly relevant for this setting where husbands constitute a significant source of support for women in reaching and staying at MWHs.(3,7) Making MWH use more husband-friendly will require advancing the literature on husband's perspectives on the feasibility and acceptability of their stay at MWHs stay and how this could impact income generation for families.

MWHs may also represent opportunities for pregnant women who need rest to obtain some without fear of judgement or reproach for shirking duties.(22) About 30% of the responses about benefits of MWH stay in our setting centred around the opportunity to rest (Appendix 7.2.1.2); this closely reflects one of the benefits of MWH stay that community health actors in the area use when advocating for MWH use.(107) Women in other settings also appreciate MWHs as places where rest is a legitimate need; as one woman in Liberia explained: "It's actually a resting place...if you have a headache you can explain to everybody and you can lie down on your bed.....it is okay."(19)

⁸ The ceremony begins with the roasting of coffee beans over charcoal and then passing around the room to immerse guests in the smoky aroma of freshly roasted coffee. The beans are then boiled in a clay *jebena* (round bottom flask). The coffee set, which includes *sini* (little coffee goblets), saucers and sugar, is placed on a *rekabot* (small table) surrounded by grass, leaves and flowers and stick of burning incense. The coffee is usually served by a woman dressed in a *habesha kemis* (traditional white garb) with her head covered along with snacks such as popcorn or roasted grain.(147)

8.4.3. *De-implementation and additional focus on health providers*

Together with HEWs, health workers, such as health centre midwives, represented important sources of health and delivery-related information for the majority of women in the trial (Appendix A7.2.1.5). Having a health worker as an information source was also found to be strongly associated with both delivery care and ANC use across large parts of the study area (Chapter 6) underscoring their important role in uptake of services. Health workers work closely with HEWs particularly in the provision of ANC services to women in this setting (78) and both cadres represent the most common entry point to MWHs for women (Chapter 7). Under the combined intervention arm, health workers were required to continue referring women to MWHs, track MWH users using MWH registers and monitor users during their stay. They were also expected to attend activities organized by local leaders if that was identified as a strategy by leaders in the intervention arms. Engagement on intervention delivery, however, was limited to one-on-one briefings conducted by the study coordinator during the MWH upgrading and set-up stage.

Building on an existing program meant that de-implementation strategies were likely necessary in addition to the MWH upgrades. This may be particularly important for our study because chance imbalance resulted in 75% of MWHs randomized to the combined intervention arm being poorly functional at baseline (Chapter 7). A relatively new area in Implementation Science, de-implementation involves identification and replacement of “low-value practices” to make room for optimally-functioning ones.(108) Additional engagement with health workers at the combined intervention sites to understand existing MWH service delivery modalities and to co-construct optimal strategies for referral and care, could have helped alleviate some of the negative effects of the imbalance. It could have also provided an opportunity to probe health workers about concerns they may have had about the additional workload upgraded MWHs might attract as has been previously reported.(109) Staff shortages and lack of equipment in rural Malawi, for instance, made it difficult for health workers to care for MWH users appropriately.(102) Furthermore, involvement of health workers in the management of MWHs has been described as an important component in well-functioning MWHs.(4,11) This precondition may have further increased the (perceived) burden on intervention health workers without any provision of support to fulfil this administrative role in addition to their clinical responsibilities. This may partially explain the reported absence of some amenities (such as the coffee ceremony or clean water) at MWHs⁺ despite provision of supplies to these sites (Appendix 7.2.1.4). Differences in work environments, available time, professional confidence and interest of health workers have been described as potential contextual factors that can modify intervention effectiveness (110); complex interventions are particularly susceptible to contextual variation not in the least because implementation practices can vary.(111)

Brainstorming strategies to counteract negative community perceptions might also have been helpful to health workers. The uncertainty around estimated delivery dates, for example, presents a challenge to health workers and women alike. It sometimes means women are unsure when to come to MWHs (5,10) or end up staying longer than anticipated.(14) Unfortunately this unpredictability is interpreted by some women as health worker incompetence (102,112) when in reality it is more a consequence of lack of equipment and low awareness among women of the date of their last menstrual period.(2,5,10)

The presence of unfinished and poorly functional MWHs in the combined intervention arms at baseline also meant that efforts to rebrand MWHs and rebuild the community's trust may also have been necessary. While the leader activities were expected to contribute to this by spreading the word about MWH upgrades, the role of health workers in this process was also likely essential. Baseline formative work uncovered some scepticism among community members about health centre management of their in-kind and cash contributions towards MWHs (112); this may have been because the system of accountability put in place was non-functional in several places. Disappointment among women and their families at the neglect and mistreatment by health workers has also been reported to affect the use of delivery care (113) but also raises concerns about the type of treatment women will receive when they stay at MWHs.(4–6,14,19) In some cases, midwife failure to attend to labouring women has even called into question the true value of MWHs.(102) An unfortunate consequence of poor-quality care is the corrosion of confidence and trust in the system.(114) Conversely, a reputation for delivering quality care has been described to encourage MWH service use.(115,116) Anticipated quality of MWH services also impacts referral practices; HEWs are less willing to refer women to MWHs viewed as deficient (2,3) and instances of health workers sending pregnant women not in active labour back home have also been documented for the same reason.(2)

8.4.4. Choice of leaders to create enabling environment

Coupling MWH upgrades with training of local leaders to improve maternal healthcare service uptake had several advantages. Firstly, efforts that combine interventions have been described to have more favourable impacts on maternal outcomes than single interventions.(117) Secondly, research at baseline suggested that women with access to social and material resources were better positioned to use MWHs (Chapter 4). This meant that simply equipping MWHs with supplies necessary for a comfortable stay would be insufficient to get all the women who could benefit from MWH stay to use them. The training component was designed to address access barriers by providing local leadership with a platform to pool resources and coordinate responses to curtail obstacles their communities faced in accessing care and/or using MWHs, thus creating an enabling environment. Thirdly, by engaging

community leaders to reflect on challenges together, the intervention workshops provided an opportunity to develop “critical consciousness” that is important for social change.(118)

The selection of the Women and Men’s Development Army members was also invaluable in this setting as this group has an extensive reach within the community. They function almost like a “buddy-system” in a context where mobile telephone ownership among women is relatively low, though on the rise (Appendix 7.2.3.7). Progress on uptake of services is difficult to track in areas, such as Ethiopia, where the vital registration system is still in its infancy(119,120) and the Development Army functions as an alternative monitoring mechanism. These leaders also have firsthand knowledge of the lived experiences of the communities being targeted for intervention delivery. In fact, some of the women leaders (at least those spoken to in four *kebeles* in Amhara region) were found to experience many of the challenges that their community counterparts do.(121)

On the other hand, Ethiopia’s complex political history and contemporary context has significant implications for the choice of intervention providers. Initially adopting a socialist model of governance, Ethiopia later began (and still is) transitioning to a more liberal-democratic configuration.(122) During this process, however, the country’s leaders have been described by some as displaying strong authoritarian tendencies (122–124), often opting to pursue a “non-negotiable approach to domestic governance.”(124) The consequences can sometimes lead to the opposite of what was at the heart of policy intentions. The command-and-control⁹ style of policy implementation employed in Ethiopia to change sanitation provides a noteworthy example of “coercive pressure” that resulted in high coverage of latrines at the expense of quality and actual health benefits.(125) Novotny and colleagues reported that close to 50% of the sampled population installed latrines simply because they were instructed to.(125) Maternal death review and reporting is another area where political pressure to demonstrate success in service delivery and gender equality, emanating from both the national and international levels, has resulted in frontline workers in Ethiopia distorting data out of fear of recrimination.(126)

The perception that the Development Army is a mechanism for government surveillance at household level has been previously reported.(66,127) While it is unclear whether women and families view the Development Army in this way, a reluctance to openly contradict state directives could create a level of wariness around those promoting its messaging, particularly in some areas. During times of crises, such as the political upheaval Ethiopia has been experiencing over the past several years, mistrust is heightened and social cohesion can be disrupted.(128) Reliance on the Development Army for health or birth-related information among our study participants was substantially lower than in *kebeles* in

⁹ This is a policy approach that functions by using regulation, prohibition, standards and enforcement rather than financial incentives to achieve goals.(148) It has its origins in environmental policies in the United States.(149)

Amhara region where 11% of women interviewed listed the WDA as a source of health information.(18) HEWs featured more prominently as trusted sources of information in our pre-trial formative research.(25) A clear recognition of the context-specific, complex relationships between families and leaders chosen for intervention delivery is, therefore, important as it could have implications for its effectiveness.

Hardly any women in our survey mentioned receiving practical support from any community groups including the Development Army, but more than 35% of women described receiving practical support from friends and neighbours (Appendix 7.2.3.5) Some of these individuals may be members of the Development Army; in our random sample of participants about 4% of women reported being WDA members (Appendix 7.2.1.5). The shortened duration and disrupted delivery of interventions could also have impacted the ability of the Development Army or religious leaders to develop into sources of health information and support as intended.

While the WDA has been deployed to extend the reach of health promotion activities conducted by HEWs, their capacity to act as information sources may also be limited without additional training. A cross-sectional assessment conducted in four regions in Ethiopia, including Oromia, concluded that WDA members had poor knowledge of essential subjects such as danger signs, newborn care or postnatal care due to insufficient training that relied upon methods that were inappropriate for a largely non-literate group.(129) Further research on the effect of intervention workshops on community and religious leader knowledge related to maternal health and care services is, thus, necessary.¹⁰

8.4.5. Support and skills for local leaders to facilitate creation of an enabling environment

Notwithstanding the disruption to implementation caused by political unrest, the leader training intervention component may have benefitted from an increased focus on building skills needed to successfully plan, coordinate and fund activities that go beyond awareness creation. A strong emphasis on the role of “improved awareness” in increasing uptake of maternal healthcare services by health workers and leaders alike was clear from project reports.(69) This tendency to accord a “privileged role to information as a driver of change” has been described as largely ineffective.(130) While families living at larger distances from MWHs were less familiar with MWHs services than those located closer to them (Appendices 7.2.1.1 & 7.2.1.3) and this may be a contributing factor to low use, other factors (such as availability of social support, transport constraints, indirect costs or quality of obstetric care) may be far more important and require strategies beyond “educating” women. Baseline formative work

¹⁰ This work, in addition to an evaluation of leader promotion practices and attitude towards maternal healthcare services, is part of the doctoral research of other PhD students on the project team.

suggested that some leaders viewed MWHs as beneficial for women from poorer families (112) betraying a lack of appreciation of the costs associated with MWH access and stay.

Exploring the potential of activities such as community-based loans for transport (131), may have gained momentum with structured sessions to identify solutions, discuss their feasibility and leverage existing community resources to put ideas into action. The simultaneous congregation of community and religious leadership from multiple *kebeles*, represented an invaluable opportunity to pool efforts towards a shared objective. Community groups such as *Iddirs*, which have traditionally been funerary associations but have recently expanded their scope (132), also exist in the area (Appendix 7.2.3.6) and could have been exploited as a medium to extend material support to families expecting babies. An understanding of the level of collective efficacy¹¹ among local leaders would have helped us better gauge existing leadership capacity and provide appropriate support as part of the training workshops. This is particularly important since collective efficacy has been reported to affect the effort dedicated by groups towards achieving goals (133) and should be considered in future work. Separating training sessions for leaders in the combined intervention arm from the training only arm could have also allowed for exploration of targeted activities to promote use of the upgraded MWHs.

Leaders may also have benefited from a discussion of strategies to hone in on their collectivistic leadership abilities¹², which are necessary in situations where leadership roles are shared.(134) While HEWs co-led training workshops, implementation of activities rested on “conjoint action by the group”, a hallmark of collectivist leadership.(134) Effective collectivist leadership requires a shared understanding of goals, clarity on roles and recognition of the competencies of co-leaders.(134) Building in reflection sessions to recognize the value of co-leaders and improve team functioning have been identified as core competencies.(134) A focus on the value of all co-leaders is likely to be particularly relevant in Ethiopia, and other patriarchal settings, as the social position of Women’s Development Army members relative Men’s Development Army and other male leaders is likely to be unequal. Uneven access to resources, opportunities for career advancement, lack of remuneration and concerns about safety have been reported as challenges unique to female volunteer workers such as the WDA.(135,136)

Correlations between utilization rates and MWHs that have strong local leadership and active community engagement from the onset have been reported. Qualitative data from Liberia suggested that highly frequented MWHs seemed to be the ones where community stakeholders were involved in

¹¹Collective efficacy provides an indication of the group’s perceived “ability to execute actions related to a common goal”(133)

¹² Collectivistic leadership represents “distributed approaches to leadership [whereby] roles and responsibilities are shared, distributed or rotated among group members”.(134)

construction of MWHs, engaged to develop strategies to encourage uptake and participated in their management.(137) However, the source of funding strongly influenced success as well; only about 35% of community-funded MWHs in Liberia were functional compared to the 75% that were funded by non-governmental organizations or United Nations consortiums.(137) Overall, less than 50% of the 119 MWH constructed nationally between 2008 and 2018 were found to be functioning; 29% had construction stalled, 13% were converted into staff quarters and 6% were abandoned illustrating the challenges associated with operating MWHs without sustainable funding. It was also interesting to note that of the 119 MWHs, only two were government funded.(137) This underlines the importance of creating local capacity to sustain MWHs if they are found to be effective.

8.5. Overall limitations and recommendations for future work

8.5.1. *Scale of contextual variation in associations between service use and explanatory factors*

The findings in Chapter 6 brought to light the diversity in the magnitude and relevance of the relationships between key explanatory factors (such as household wealth and companion support) and service use across localities. However, an important limiting factor in this work was that the spatial scale at which relationships operated was assumed to be the same regardless of the factor. This assumption, operationalized through the use of a single bandwidth parameter in the geographically weighted regression (GWR) analysis, disregards the possibility that the scale at which relationship variability occurs may differ depending on the factor considered. The bandwidth articulates the spatial scale at which a relationship is thought to operate at by specifying which locations are considered neighbours when generating local estimates. It also defines the relative contribution that each “neighbour” makes in the local estimation process. In this way larger bandwidths imply that variation in the relationship between an explanatory variable and service use is expected to be at a larger scale such as an entire PHCU or even a district. Conversely, smaller bandwidths would be selected when relationships vary at between *kebeles*.

The optimal bandwidths obtained for ANC, delivery care and PNC use were fairly large ranging between 927 and 1560 nearest households meaning that relationships between all explanatory factors and service use were expected to vary at large scales. However, this may not accurately reflect the scale at which all relationships operate in reality. For instance, it is possible that the association between postpartum danger sign awareness and PNC use operates at a much more localized scale because women living in different *gares* (neighbourhoods within *kebeles*) may have different exposures to HEWs depending on how far they live from health posts. Women from *gares* within easy access of health posts are probably more likely to receive counselling on danger signs through home visits or during their trips to the health post than those living in more isolated *gares*. The large bandwidth used to model all explanatory factors associated with PNC use means that more localized variation is likely missed.

Herein lies the significant advantage of multi-scale GWR models that permit the selection of optimal bandwidths for each explanatory factor separately.(138,139) Multiscale GWR models for binary outcomes have not yet been developed but are likely to be available in the future.

With the use of larger datasets GWR models could be used to characterize the variation in factors that affect MWH use between different areas and used in conjunction with delivery care GWR models to assist with prioritization of cost-effective strategies to improve institutional births. These models could also inform appropriate placement of future MWHs in areas that would benefit from these services and allow sub-national policy implementers to determine if MWHs meet the specific needs of their populations.

8.5.2. *Eligibility criteria and distance*

The parallel project objective of evaluating the impact of the leader training intervention on uptake of maternal healthcare services directed the decision to include the leader training as a separate intervention arm. It also partially informed the formulation of eligibility criteria, which did not restrict participation by distance as this would have narrowed the generalizability of effect of the leader training intervention component. Additionally, the Ethiopian national guidelines on MWH admission criteria include women suspected to be at risk for obstetric complications (101) which meant that using distance-based eligibility criteria would have further limited the applicability of trial findings. However, ambivalence around the suitability of this risk-based criterion for admission to MWHs located at health centres (with limited capacity to handle complications) became apparent at meetings with the National Advisory Committee¹³. This uncertainty among policy-makers could be a contributing factor to the variation in referral practices observed at PHCU-level. Some providers focussed on referrals to women living far away while others included women who were believed to be at higher risk for complications (such as those with twin pregnancies); some health centres simply used MWHs as an extension of the insufficiently-sized labour wards to temporarily house women not yet in the active stages of labour.(140)

Post-hoc analysis, which substituted calculated distances for estimated travel time, suggested that women living within a kilometre of a health centre had lower odds of MWH use (Appendix 4.2). The implication of this was that for almost one-fifth of the trial participants (Appendix 7.2.3.3) MWH stay may have been irrelevant in terms of relieving geographical access constraints. This could have diminished some of the impact of the combined intervention on institutional births. Future work on

¹³ An advisory committee consisting of national level policy makers from the Ethiopian Federal Ministry of Health, Ethiopian Institute of Public Health and Ministry of Science and Technology was assembled in 2016 to serve as a platform to engage stakeholders, share preliminary findings, solicit feedback and disseminate final results during annually organized meetings.

MWH effectiveness in Ethiopia, thus, may benefit from the inclusion of distance-based eligibility criteria. Sub-group analyses among trial participants living at least one kilometre away from health centres has been planned to determine if that changes intervention effectiveness estimates.

8.6. Conclusions

To ensure that “no one is left behind” will require knowing who is being left behind and where they are. Through this work I have demonstrated the relevance of context at a more granular scale than typically considered for policy formulation and implementation. The heterogeneity in local context results in different configurations of factors influencing service use and results in a range of responses to changes in conditions between localities. This means that applying uniform solutions across regions within countries is unlikely to be effective in “closing the gap” in access to care. While there is global recognition of the need for countries to adapt global maternal healthcare policies to suit their national contexts, additional emphasis on sub-national tailoring will be required to reduce these within-country disparities. Countries such as Ethiopia that have decentralized governance systems are ideally structured to launch locally relevant responses through sub-national units such as regions and *woredas*. However, to facilitate effective local policy implementation, subnational governments will also require fiscal independence, human resources and policy decision spaces (141), in addition to data about geographical and social dimensions of access to care.

Maternity waiting homes provide an interesting example of a global strategy to improve women’s access to obstetric care that has strong external partner support. However, a disproportionate influence of “donors” has been described as one challenge that local policy makers face in advancing women’s health using strategies that are appropriate to the “realities on the ground”.(141) MWHs have been scaled-up across Ethiopia without strong evidence of effect (104,142,143) or comprehensive sub-national needs assessments to determine where they may be most effective. The need to generate strong evidence about their effectiveness in improving women’s access to facility-based delivery care still remains. Trials are likely to provide the most conclusive evidence base around effectiveness. However, they will need a pragmatic and inclusive approach to the design of sustainable MWH models in order to produce meaningful results for this complex intervention. Incorporating process evaluations, ensuring appropriate duration for intervention delivery and evaluation as well as building in contingencies for disruption will also be critical particularly in low-resource settings. Partnerships between international and local institutions, such as the one employed in our trial, are also helpful for ensuring that local priorities are recognized and evidence generation is contextually relevant.(144)

It is also unlikely that MWHs can equitably improve access to care if complementary interventions specifically addressing geographical and social barriers are not also in place. In the absence of these,

MWH users are likely to be skewed towards those who have the financial and social resources to surmount these challenges leaving behind those most vulnerable to their circumstances. Additionally, if MWHs are intended as platforms to link women at high risk for complications to care, then the type of health facility that they are attached to (health centre versus hospital) is an important consideration given the poor quality of emergency obstetric care that is common at lower level facilities.(75,84) Referral strategies will also need to be adapted to match the level of care available; if MWHs are located at health centres where comprehensive emergency obstetric care is not provided and functioning ambulances are not readily available to transfer complicated cases, referring high risk women to these MWHs is likely inappropriate and unethical. A less fragmented approach to awareness creation about MWHs is also needed for localities that choose this strategy; while discussing birth preparedness, community health workers and healthcare providers need to alert women to the option of MWH stay if suitable. There is, therefore, a need to determine how MWHs fit in with other strategies to improve access to maternal healthcare adopted by sub-national regions in response to their population's needs.

In conclusion, to equitably improve all women's access to maternal healthcare services, explicit consideration of contextual differences in needs and obstacles will be necessary in evidence generation and policy implementation efforts. While sustainable, community co-designed, optimally situated and appropriately promoted MWHs integrated into the continuum of health services may be one option to improve access to care in some localities, the need for evidence of their effectiveness remains.

8.7. Chapter References

1. Lee ACC, Lawn JE, Cousens S, Kumar V, Osrin D, Bhutta ZA, et al. Linking families and facilities for care at birth: What works to avert intrapartum-related deaths? *Int J Gynaecol Obstet.* 2009;107((Suppl1) S65-S88).
2. Bergen N, Abebe L, Asfaw S, Kiros G, Kulkarni MA. Maternity waiting areas – serving all women ? Barriers and enablers of an equity-oriented maternal health intervention in Jimma Zone, Ethiopia. *Glob Public Health.* 2019;14(10):1509–23.
3. Kebede KM, Mihrete KM. Factors influencing women's access to the maternity waiting home in rural Southwest Ethiopia: a qualitative exploration. *BMC Pregnancy Childbirth.* 2020;20(296).
4. Lori JR, Munro-Kramer ML, Mdluli EA, Musonda GK, Boyd CJ. Developing a community driven sustainable model of maternity waiting homes for rural Zambia. *Midwifery.* 2016;41:89–95.
5. Kyokan M, Whitney-long M, Kuteh M, Raven J. Community-based birth waiting homes in Northern Sierra Leone: Factors influencing women's use. *Midwifery.* 2016;39:49–56.
6. Mphande I. Quality of Maternal Care at Maternity Waiting Homes in Chitipa district in Northern Malawi. In: *Inter-professional Education & Collaborative Practice for Africa.* Nairobi, Kenya; 2019.
7. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J.* 2012;50(3):209–19.

8. Selbana DW, Derese M, Endalew ES, Gashaw BT. A Culturally Sensitive and Supportive Maternity Care Service Increases the Uptake of Maternity Waiting Homes in Ethiopia. *Int J Womens Health*. 2020;12:813–21.
9. Endalew GB, Gebretsadik AL, Gizaw TA. Intention to use Maternity Waiting Home among Pregnant Women in Jimma District, Southwest Ethiopia. *Glob J Med Res*. 2016;16(6):1–8.
10. Eckermann E, Deodato G. Maternity waiting homes in Southern Lao PDR: The unique “silk home.” *J Obstet Gynaecol Res*. 2008;34(5):767–75.
11. Chibuye PS, Bazant ES, Wallon M, Rao N, Fruhauf T. Experiences with and expectations of maternity waiting homes in Luapula Province, Zambia: a mixed – methods, cross-sectional study with women, community groups and stakeholders. *BMC Pregnancy Childbirth*. 2018;18(42).
12. Garcia Prado A, Cortez R. Maternity waiting homes and institutional birth in Nicaragua: policy options and strategic implications. *Int J Health Plann Manage*. 2012;27:150–66.
13. Ibáñez-Cuevas M, Heredia-Pi IB, Meneses-Navarro S, Pelcastre-Villafuerte B, González-Block MA. Labor and delivery service use : indigenous women’s preference and the health sector response in the Chiapas Highlands of Mexico. *Int J Equity Health*. 2015;14(156).
14. Penn-Kekana L, Pereira S, Hussein J, Bontogon H, Chersich M, Munjanja S, et al. Understanding the implementation of maternity waiting homes in low- and middle-income countries: A qualitative thematic synthesis. *BMC Pregnancy Childbirth*. 2017;17(269).
15. Ruiz MJ, van Dijk MG, Berdichevsky K, Munguía A, Burks C, García SG. Barriers to the use of maternity waiting homes in indigenous regions of Guatemala: A study of users’ and community members’ perceptions. *Cult Heal Sex*. 2013;15(2):205–18.
16. Getachew B, Liabsuetrakul T. Health care expenditure for delivery care between maternity waiting home users and nonusers in Ethiopia. *Int J Heal Plan Manag*. 2019;34:e1334–45.
17. Kaiser JL, McGlasson KL, Rockers PC, Fong RM, Ngoma T, Hamer DH, et al. Out-of-pocket expenditure for home and facility-based delivery among rural women in Zambia: a mixed-methods, cross-sectional study. *Int J Womens Health*. 2019;11:411–30.
18. Endayehu M, Yitayal M, Debie A. Intentions to use maternity waiting homes and associated factors in Northwest Ethiopia. *BMC Pregnancy Childbirth*. 2020;20(281).
19. Lori JR, Wadsworth AC, Munro ML, Rominski S. Promoting access: The use of maternity waiting homes to achieve safe motherhood. *Midwifery*. 2013;29:1095–102.
20. Getachew B, Liabsuetrakul T, Gebrehiwot Y. Association of maternity waiting home utilization with women’s perceived geographic barriers and delivery complications in Ethiopia. *Int J Heal Plan Manag*. 2019;1–12.
21. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: Women’s beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;12(61).
22. Tiruneh GT, Taye BW, Karim AM, Betemariam WA, Zemichael NF, Wereta TG, et al. Maternity waiting homes in Rural Health Centers of Ethiopia: The situation, women’s experiences and challenges. *J Heal Dev*. 2016;30(1):19–28.
23. Hill Z, Amare Y, Scheelbeek P, Schellenberg J. ‘People have started to deliver in the facility these days’: a qualitative exploration of factors affecting facility delivery in Ethiopia. *BMJ Open*. 2019;9(e025516).
24. Macintyre S, Ellaway A, Cummins S. Place effects on health : how can we conceptualise , operationalise and measure them ? *Soc Sci Med*. 2002;55:125–39.
25. Asfaw S, Morankar S, Abera M, Mamo A, Abebe L, Bergen N, et al. Talking health: trusted health messengers and effective ways of delivering health messages for rural mothers in

- Southwest Ethiopia. *Arch Public Heal*. 2019;77(8).
26. Okedo-Alex IN, Akamike IC, Ezeanosike OB, Uneke CJ. Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. *BMJ Open*. 2019 Oct;9(10):e031890.
 27. Guliani H, Sepehri A, Serieux J. Determinants of prenatal care use: Evidence from 32 low-income countries across Asia, Sub-Saharan Africa and Latin America. *Health Policy Plan*. 2014;29:589–602.
 28. Diamond-Smith N, Sudhinaraset M. Drivers of facility deliveries in Africa and Asia: regional analyses using the demographic and health surveys. *Reprod Health*. 2015;12(6).
 29. Mehari AM. Levels and Determinants of Use of Institutional Delivery Care Services among Women of Childbearing Age in Ethiopia: Analysis of EDHS 2000 and 2005 Data. DHS Working Papers. Calverton, Maryland; 2013.
 30. Melaku YA, Weldearegawi B, Tesfay FH, Abera SF, Abraham L, Aregay A, et al. Poor linkages in maternal health care services-evidence on antenatal care and institutional delivery from a community-based longitudinal study in Tigray region, Ethiopia. *BMC Pregnancy Childbirth*. 2014;14(418).
 31. Yebyo HG, Gebreselassie MA, Kahsay AB. Individual and community-level predictors of home delivery in Ethiopia: A multilevel mixed-effects analysis of the 2011 Ethiopia National Demographic and Health Survey. DHS Working Papers No. 104. 2014.
 32. Wilunda C, Quaglio G, Putoto G, Takahashi R, Calia F, Abebe D, et al. Determinants of utilisation of antenatal care and skilled birth attendant at delivery in South West Shoa Zone, Ethiopia: a cross sectional study. *Reprod Health*. 2015;12(74).
 33. Mezmur M, Navaneetham K, Letamo G, Bariagaber H. Individual, household and contextual factors associated with skilled delivery care in Ethiopia: Evidence from Ethiopian demographic and health surveys. *PLoS One*. 2017;12(9).
 34. Wado YD. Women's autonomy and reproductive healthcare-seeking behavior in Ethiopia. DHS Working Papers. 2013.
 35. Dutamo Z, Assefa N, Egata G. Maternal health care use among married women in Hossaina, Ethiopia. *BMC Health Serv Res*. 2015;15(365).
 36. Tiruneh FN, Chuang K, Chuang Y. Women's autonomy and maternal healthcare service utilization in Ethiopia. *BMC Health Serv Res*. 2017;17(718).
 37. Nigusie A, Azale T, Yitayal M. Institutional delivery service utilization and associated factors in Ethiopia: a systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2020;20(364).
 38. Benova L, Owolabi O, Radovich E, Wong KLM, Macleod D, Langlois E V., et al. Provision of postpartum care to women giving birth in health facilities in sub-Saharan Africa: A cross-sectional study using Demographic and Health Survey data from 33 countries. *PLOS Med*. 2019;16(10):e1002943.
 39. Chaka EE, Abdurahman AA, Nedjat S, Majdzadeh R. Utilization and Determinants of Postnatal Care Services in Ethiopia : A Systematic Review and Meta-Analysis. *Ethiop J Heal Sci*. 2019;29(1):935–44.
 40. Emiru AA, Alene GD, Debelew GT. Women's retention on the continuum of maternal care pathway in west Gojjam zone, Ethiopia: multilevel analysis. *BMC Pregnancy Childbirth*. 2020;20(258).
 41. Haile D, Kondale M, Andarge E, Tunje A, Fikadu T, Boti N. Level of completion along continuum of care for maternal and newborn health services and factors associated with it among women in Arba Minch Zuria woreda , Gamo zone, Southern Ethiopia : A community based cross- sectional study. *PLoS One*. 2020;15(6):e0221670.
 42. Muluneh GA, Kassa GM, Alemayehu GA, Merid MW. High dropout rate from maternity

- continuum of care after antenatal care booking and its associated factors among reproductive age women in Ethiopia: evidence from Demographic and Health Survey 2016. *PLoS One*. 2020;15(6):e0234741.
43. Tekelab T, Chojenta C, Smith R, Loxton D. Factors affecting utilization of antenatal care in Ethiopia: A systematic review and meta- analysis. *PLoS One*. 2019;14(4):e0214848.
 44. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia : a multilevel analysis. *BMC Int Heal Hum Rights*. 2013;13(20).
 45. Stephenson R, Baschieri A, Clements S, Hennink M, Madise N. Contextual influences on the use of health facilities for childbirth in Africa. *Am J Public Health*. 2006;96:84–93.
 46. Aremu O, Lawoko S, Dalal K. Neighborhood socioeconomic disadvantage, individual wealth status and patterns of delivery care utilization in Nigeria: a multilevel discrete choice analysis. *Int J Womens Health*. 2011;3:167–74.
 47. Tunstall HVZ, Shaw M, Dorling D. Places and health. *J Epidemiol Community Heal*. 2004;58:6–10.
 48. Freedman LP, Schaaf M. Act global, but think local:accountability at the frontlines. *Reprod Health Matters*. 2013;21(42):103–12.
 49. Eckersley P. A new framework for understanding subnational policy-making and local choice. *Policy Stud*. 2017;38(1):76–90.
 50. Rohrer K. Strategizing for health at sub-national level. In: Schmets G, editor. *Strategizing national health in the 21st century: a handbook*. Geneva, Switzerland; 2016.
 51. Abimbola S, Baatiema L, Bigdeli M. The impacts of decentralization on health system equity, efficiency and resilience: a realist synthesis of the evidence. *Heal Policy Plan*. 2019;605–17.
 52. Ali K, Partridge MD, Olfert MR. Can geographically weighted regressions improve regional analysis and policy making? *Int Reg Sci Rev*. 2007;30(3):300–29.
 53. Henriksson DK, Ayebare F, Waiswa P, Peterson SS, Tumushabe EK, Fredriksson M. Enablers and barriers to evidence based planning in the district health system in Uganda; perceptions of district health managers. *BMC Health Serv Res*. 2017;17(103).
 54. Henriksson DK, Peterson SS, Waiswa P, Fredriksson M. Decision-making in district health planning in Uganda: does use of district-specific evidence matter? *Heal Res Policy Syst*. 2019;17(57).
 55. Scott N. Impact Evaluation of Maternity Homes Access in Zambia (MAHMAZ) [Internet]. *ClinicalTrials.gov*. 2015. Available from: <https://clinicaltrials.gov/ct2/show/NCT02620436>
 56. Lori JR, Perosky J, Munro-kramer ML, Veliz P, Musonda G, Kaunda J, et al. Maternity waiting homes as part of a comprehensive approach to maternal and newborn care : a cross-sectional survey. *BMC Pregnancy Childbirth*. 2019;19(228).
 57. Serbanescu F, Goldberg HI, Danel I, Wuhib T, Marum L, Obiero W, et al. Rapid reduction of maternal mortality in Uganda and Zambia through the saving mothers, giving life initiative: results of year 1 evaluation. *BMC Pregnancy Childbirth*. 2017;17(42).
 58. Conlon CM, Serbanescu F, Marum L, Healey J, Labrecque J, Hobson R, et al. *Saving Mothers, Giving Life: It Takes a System to Save a Mother* (republication). *Glob Heal Sci Pract*. 2019;7(1):20–40.
 59. Zambia Central Statistical Office. 2018 National Survey on Access and Usage of information and communication technologies by households and individuals. 2018.
 60. Scott NA, Kaiser JL, Vian T, Bonawitz R, Fong RM, Ngoma T, et al. Impact of maternity waiting homes on facility delivery among remote households in Zambia: protocol for a quasiexperimental, mixed-methods study. *BMJ Open*. 2018;8:e022224.

61. Bonawitz R, Mcglasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia : A mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS One*. 2019;14(11):e0225523.
62. United Nations Population Fund. Connecting mothers-to-be with health clinics in rural Zambia. 2014.
63. Jacobs C, Michelo C, Moshabela M. Implementation of a community-based intervention in the most rural and remote districts of Zambia:a process evaluation of safe motherhood action groups. *Implement Sci*. 2018;13(74).
64. Alonge O, Rodriguez DC, Reveiz L, Peters DH, Brandes N, Geng E. How is implementation research applied to advance health in low- income and middle-income countries? *BMJ Glob Heal*. 2019;4(e001257).
65. Kurji J, Gebretsadik LA, Wordofa MA, Morankar S, Bedru KH, Bulcha G, et al. Effectiveness of upgraded maternity waiting homes and local leader training on improving institutional births : a cluster- randomized controlled trial in Jimma ,. *BMC Public Health*. 2020;20(1593).
66. Fleischman J, Peck K. *Imperiling Progress: How Ethiopia's Response to Political Unrest Could Undermine Its Health Gains*. Washington; 2016.
67. Østby G, Urdal H, Tollefsen AF, Kotsadam A, Belbo R, Ormhaug C. Organized Violence and Institutional Child Delivery : Micro-Level Evidence From Sub-Saharan Africa , 1989 – 2014. *Demography*. 2018;55:1295–316.
68. Wild K, Kurji J. Maternity waiting homes in times of crisis : Can current models meet women ' s needs ? *Women and Birth*. 2020;1146.
69. Labonté R, Gebretsadik LA, Morankar S, Bergen N, Mamo A, Asfaw S, et al. Internal Project Report: Summary of qualitative data at endline. Jimma, Ethiopia & Ottawa, Canada; 2020.
70. Federal Democratic Republic of Ethiopia Ministry of Health. Health Extension Worker Training Manual. Addis Ababa; 2003.
71. Ibrhim MA, Demissie M, Medhanyie AA, Worku A, Berhane Y. Reasons for low level of skilled birth attendance in Afar pastoralist community, North East Ethiopia: a qualitative exploration. *Pan Afr Med J*. 2018;30(51).
72. Ahmed M, Demissie M, Worku A, Abrha A, Berhane Y. Socio-cultural factors favoring home delivery in Afar pastoral community , northeast Ethiopia: A Qualitative Study. *Reprod Health*. 2019;16(171).
73. Gurara M, Muylldermans K, Jacquemyn Y, van Geertruyden J-P, Draulans V. Traditional birth attendants' roles and homebirth choices in Ethiopia: A qualitative study. *Women and Birth*. 2020;e464–72.
74. Kifle D, Azale T, Gelaw YA, Melsew YA. Maternal health care service seeking behaviors and associated factors among women in rural Haramaya District,Eastern Ethiopia:a triangulated community-based cross-sectional study. *Reprod Health*. 2017;14(6).
75. Ministry of Health, Columbia University, Ethiopian Public Health Institute. Ethiopian emergency obstetric and newborn care (EmONC) assessment. Addis Ababa & New York; 2017.
76. Belda SS, Gebremariam MB. Birth preparedness, complication readiness and other determinants of place of delivery among mothers in Goba District, Bale Zone, South East Ethiopia. *BMC Pregnancy Childbirth*. 2016;16(73).
77. Shiferaw BB, Modiba LM. Why do women not use skilled birth attendance service ? An explorative qualitative study in north West Ethiopia. *BMC Pregnancy Childbirth*. 2020;20(633).

78. Bergen N, Hudani A, Asfaw S, Mamo A, Kiros G, Kurji J, et al. Promoting and delivering antenatal care in rural Jimma Zone, Ethiopia: a qualitative analysis of midwives' perceptions. *BMC Health Serv Res*. 2019;19(719).
79. Datiko DG, Bunte EM, Birrie GB, Kea AZ, Steege R, Taegtmeier M, et al. Community participation and maternal health service utilization: lessons from the health extension programme in rural southern Ethiopia. *J Glob Heal Reports*. 2019;3(e201902).
80. Gebrehiwot T, Sebastian MS, Edin K, Goicolea I. Health workers' perceptions of facilitators of and barriers to institutional delivery in Tigray, Northern Ethiopia. *BMC Pregnancy Childbirth*. 2014;14(137).
81. Reitsma A, Simioni J, Brunton G, Kaufman K, Hutton EK. Maternal outcomes and birth interventions among women who begin labour intending to give birth at home compared to women of low obstetrical risk who intend to give birth in hospital: A systematic review and meta-analyses. *EClinicalMedicine*. 2020;21(100319).
82. World Health Organization. WHO recommendations: Intrapartum care for a positive childbirth experience. Geneva, Switzerland; 2018.
83. Shaw D, Guise J-M, Shah N, Gemzell-Danielsson K, Joseph KS, Levy B, et al. Drivers of maternity care in high-income countries: can health systems support woman-centred care? *Lancet*. 2016;S0140-6736.
84. Dewan SR-, Nimako K, Twum- NAY, Amatya A, Langer A, Kruk M. Health system redesign for maternal and newborn survival: rethinking care models to close the global equity gap. *BMJ Glob Heal*. 2020;5:e002539.
85. Graham, W. J., Bell, J. S., & Bullough CH. Can skilled attendance at delivery reduce maternal mortality in developing countries. *Stud Heal Serv Organ Policy*. 2001;17:97–130.
86. Bohren MA, Hunter EC, Munthe-Kaas HM, Souza J, Vogel JP, Gülmezoglu A. Facilitators and barriers to facility-based delivery in low- and middle-income countries: a qualitative evidence synthesis. *Reprod Health*. 2014;11(71).
87. Kaba M, Bulto T, Tafesse Z, Lingerh W, Ali I. Sociocultural determinants of home delivery in Ethiopia: a qualitative study. *Int J Womens Health*. 2016;8:93–102.
88. Bedford J, Gandhi M, Admassu M, Girma A. "A normal delivery takes place at home": A qualitative study of the location of childbirth in rural Ethiopia. *Matern Child Health J*. 2013;17(2):230–9.
89. Downe S, Finlayson K, Oladapo O, Bonet M. What matters to women during childbirth: A systematic qualitative review. *PLoS One*. 2018;13(4):e0194906.
90. Bradley S, Mccourt C, Rayment J, Parmar D. Disrespectful intrapartum care during facility-based delivery in sub-Saharan Africa: A qualitative systematic review and thematic synthesis of women's perceptions and experiences. *Soc Sci Med*. 2016;169:157–70.
91. Dzomeku VM, Bemah A, Mensah B, Nakua EK, Agbadi P, Lori JR, et al. "I wouldn't have hit you, but you would have killed your baby": exploring midwives' perspectives on disrespect and abusive care in Ghana. *BMC Pregnancy Childbirth*. 2020;20(15).
92. Lusambili AM, Naanyu V, Wade TJ, Mossman L, Mantel M, Pell R, et al. Deliver on Your Own: Disrespectful Maternity Care in rural Kenya. *PLoS One*. 2020;15(1):e0214836.
93. Amroussia N, Hernandez A, Vives-cases C, Goicolea I. "Is the doctor God to punish me ?!" An intersectional examination of disrespectful and abusive care during childbirth against single mothers in Tunisia. 2017;1–12.
94. Bohren MA, Mehrtash H, Fawole B, Maung TM, Balde MD, Maya E, et al. How women are treated during facility-based childbirth in four countries: a cross-sectional study with labour observations and community-based surveys. *Lancet*. 2019;394:1750–63.

95. Bohren MA, Vogel JP, Hunter EC, Lutsiv O, Makh SK, Diniz A, et al. The mistreatment of women during childbirth in health facilities globally: a mixed-methods systematic review. *PLoS Med.* 2015;12(6):e1001847.
96. Kassa ZY, Husen S. Disrespectful and abusive behavior during childbirth and maternity care in Ethiopia: a systematic review and meta-analysis. *BMC Res Notes.* 2019;12(83).
97. Sheferaw ED, Bazant E, Gibson H, Fenta HB, Ayalew F, Belay TB, et al. Respectful maternity care in Ethiopian public health facilities. *Reprod Health.* 2017;14(60).
98. Mengesha MB, Desta AG, Maeruf H, Hidru HD. Disrespect and Abuse during Childbirth in Ethiopia: A Systematic Review. *Biomed Res Int.* 2020;2020:8186070.
99. Shiferaw S, Spigt M, Godefrooij M, Melkamu Y, Tekie M. Why do women prefer home births in Ethiopia? *BMC Pregnancy Childbirth.* 2013;13(5).
100. Roro MA, Hassen EM, Lemma AM, Gebreyesus SH, Afework MF. Why do women not deliver in health facilities: a qualitative study of the community perspectives in south central Ethiopia? *BMC Res Notes.* 2014;7(556).
101. Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa; 2015.
102. Mphande I. Analysing quality of maternal care through maternity waiting homes in Chitipa district. University of Malawi; 2017.
103. McIntosh N, Gruits P, Oppel E, Shao A. Built spaces and features associated with user satisfaction in maternity waiting homes in Malawi. *Midwifery.* 2018;62:96–103.
104. World Health Organization. WHO Recommendations on health promotion interventions for maternal and newborn health. Geneva, Switzerland; 2015.
105. The Partnership for Maternal Newborn & Child Health. Engaging men and boys in RMNCH Knowledge summary: women's & children's health. 2013.
106. Yargawa J, Leonardi-Bee J. Male involvement and maternal health outcomes: systematic review and meta-analysis. *J Epidemiol Community Heal.* 2015;69:604–12.
107. Mamo A, Morankar S, Asfaw S, Bergen N, Kulkarni MA, Abebe L, et al. How do community health actors explain their roles? Exploring the roles of community health actors in promoting maternal health services in rural Ethiopia. *BMC Health Serv Res.* 2019;19(724).
108. Upvall MJ, Bourgault AM. De-implementation: A concept analysis. *Nurs Forum.* 2018;53:376–82.
109. Kaiser JL, Fong RM, Ngoma T, Mcglasson KL, Biemba G, Hamer DH, et al. The effects of maternity waiting homes on the health workforce and maternal health service delivery in rural Zambia: a qualitative analysis. *Hum Resour Health.* 2019;17(93).
110. Hawe P, Shiell A, Riley T, Gold L. Methods for exploring implementation variation and local context within a cluster randomised community intervention trial. *J Epidemiol Community Heal.* 2004;58:788–94.
111. Hawe P. Lessons from Complex Interventions to Improve Health. *Annu Rev Psychol.* 2015;36:307–23.
112. Bergen N, Mamo A, Asfaw S, Labonté R, Gebretsadik LA, Sudhakar M. Internal project reports: Baseline Qualitative Findings. Jimma, Ethiopia & Ottawa, Canada; 2019.
113. Dahab R, Sakellariou D. Barriers to Accessing Maternal Care in Low Income Countries in Africa: A Systematic Review. *Int Journals Environ Res Public Heal.* 2020;17(4292).
114. Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-DeWan S, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. *Lancet Glob Heal.* 2018;6:e1196–252.

115. Vermeiden T, Schiffer R, Langhorst J, Klappe N, Asera W, Getnet G, et al. Facilitators for maternity waiting home utilisation at Attat Hospital: a mixed-methods study based on 45 years of experience. *Trop Med Int Heal*. 2018;23(12):1332–41.
116. Schooley J, Mundt C, Wagner P, Fullerton J, O'Donnell M. Factors influencing health care-seeking behaviours among Mayan women in Guatemala. *Midwifery*. 2009;25(4):411–21.
117. Nyamtema AS, Urassa DP, van Roosmalen J. Maternal health interventions in resource limited countries: A systematic review of packages, impacts and factors for change. *BioMedCentral Pregnancy and Childbirth*. 2011;11(30).
118. Gram L, Fitchett A, Ashraf A, Daruwalla N, Osrin D. Promoting women's and children's health through community groups in low-income and middle-income countries: a mixed methods systematic review of mechanisms, enablers and barriers. *BMJ Glob Heal*. 2019;4(e001972).
119. UNICEF. First ever civil registration and vital statistics day observed in Ethiopia [Internet]. 2018 [cited 2020 Apr 6]. Available from: <https://www.unicef.org/ethiopia/press-releases/first-ever-civil-registration-and-vital-statistics-day-observed-ethiopia>
120. World Bank, World Health Organization. Global Civil Registration and Vital Statistics Scaling up Investment Plan 2015 – 2024. 2014.
121. Maes K, Closser S, Tesfaye Y, Gilbert Y, Abesha R. Volunteers in Ethiopia's women's development army are more deprived and distressed than their neighbors: cross-sectional survey data from rural Ethiopia. *BMC Public Health*. 2018;18(258).
122. Ottaway M. The Ethiopian Transition: Democratization or New Authoritarianism? *Northeast Afr Stud*. 1995;2(3):67–84.
123. Cabestan J-P. China and Ethiopia: Authoritarian affinities and economic cooperation. *China Perspect*. 2012;4(92):53–62.
124. Brown S, Fisher J. Aid donors, democracy and the developmental state in Ethiopia. *Democratization*. 2020;27(2):185–203.
125. Novotný J, Humnalova H, Kolomazníková J. The social and political construction of latrines in rural Ethiopia. *J Rural Stud*. 2018;
126. Melberg A, Mirkuzie AH, Sisay TA, Sisay MM, Moland KM. 'Maternal deaths should simply be 0': politicization of maternal death reporting and review processes in Ethiopia. *Health Policy Plan*. 2019;34:492–8.
127. Maes K, Closser S, Vorel E, Tesfaye Y. A Women's Development Army: Narratives of Community Health Worker Investment and Empowerment in Rural Ethiopia. *Stud Comp Int Dev*. 2015;50:455–78.
128. Rohwerder B. Secondary impacts of major disease outbreaks in low- and middle-income countries. 2020.
129. Ashebir F, Medhanyie AA, Mulugeta A, Åke L, Berhanu D. Women's development group leaders' promotion of maternal, neonatal and child health care in Ethiopia: a cross-sectional study. *Glob Health Action*. 2020;13(1748845).
130. Kelly MP, Barker M. Why is changing health-related behaviour so difficult? *Public Health*. 2016;136:109–16.
131. Nwolise CH, Hussein J, Kanguru L, Bell J, Patel P. The effectiveness of community-based loan funds for transport during obstetric emergencies in developing countries: a systematic review. *Heal Policy Plan*. 2015;30:946–55.
132. Pankhurst A. The Emergence, Evolution and Transformations of iddir Funeral Associations in Urban Ethiopia. *J Ethiop Stud*. 2008;41(1/2 Special Issue (Jun-Dec)):143–85.

133. Delea MG, Sclar GD, Woreta M, Haardörfer R, Nagel CL, Caruso BA, et al. Collective Efficacy: Development and Validation of a Measurement Scale for Use in Public Health and Development Programmes. *Int J Environ Res Public Health*. 2018;15(2139).
134. Brún A De, Donovan RO, Mcauliffe E. Interventions to develop collectivistic leadership in healthcare settings: a systematic review. *BMC Health Serv Res*. 2019;19(72).
135. Steege R, Taegtmeier M, Mccollum R, Hawkins K, Ormel H, Kok M, et al. How do gender relations affect the working lives of close to community health service providers? Empirical research, a review and conceptual framework. *Soc Sci Med*. 2018;209:1–13.
136. Closser S, Napier H, Maes K, Abesha R, Gebremariam H, Backe G, et al. Does volunteer community health work empower women? Evidence from Ethiopia's Women's Development Army. *Heal Policy Plan*. 2019;34:298–306.
137. Lori JR, Perosky JE, Rominski S, Munro-Kramer ML, Cooper F, Kofa A, et al. Maternity waiting homes in Liberia: Results of a countrywide multi-sector scale-up. *PLoS One*. 2020;15(6):e0234785.
138. Fotheringham AS, Yang W, Kang W. Multiscale Geographically Weighted Regression (MGWR). *Ann Am Assoc Geogr*. 2017;107(6):1247–65.
139. Oshan TM, Li Z, Kang W, Wolf LJ, Fotheringham SA. MGWR: A Python Implementation of Multiscale Geographically Weighted Regression for Investigating Process Spatial Heterogeneity and Scale. *Int J Geo-information*. 2019;6(269).
140. Kurji J. Internal project report: summary of observations during field visits to study MWHs in Jimma Zone, Ethiopia. Ottawa; 2017.
141. Qiu M, Sawadogo-Lewis T, Ngale K, Cane RM, Magaço A, Robertson T. Obstacles to advancing women's health in Mozambique: a qualitative investigation into the perspectives of policy makers. *Glob Heal Res Policy*. 2019;4(28).
142. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
143. Buser JM, Lori JR. Newborn Outcomes and Maternity Waiting Homes in Low and Middle-Income Countries: A Scoping Review. *Matern Child Health J*. 2016;1–10.
144. Malla C, Aylward P, Ward P. Knowledge translation for public health in low- and middle-income countries: a critical interpretive synthesis. *Glob Heal Res Policy*. 2018;3(29).
145. Steyer R, Mayer A, Fiege C. Causal inference on total, direct and indirect effects. In: Michalos AC, editor. *Encyclopedia of Quality of Life and Well-being Research*. Dordrecht: Springer; 2014. p. 606–30.
146. Sialubanje C, Massar K, Horstkotte L, Hamer DH, Ruiter RAC. Increasing utilisation of skilled facility-based maternal healthcare services in rural Zambia: the role of safe motherhood action groups. *Reprod Health*. 2017;14(81).
147. Goldsmiths SH. Coffee and the State in Rural Ethiopia. *Anthropol Matters J*. 2018;18(1).
148. OECD. Command-and-Control policy [Internet]. Glossary of Statistical Terms. 2001 [cited 2020 Nov 23]. Available from: <https://stats.oecd.org/glossary/>
149. Rice University. Command-and-control regulation [Internet]. Principles of Economics. [cited 2020 Nov 23]. Available from: <https://opentextbc.ca/principlesofeconomics/chapter/12-2-command-and-control-regulation/>

Appendices

Chapter 1. Introduction

A1.1. Overview of the Safe Motherhood Project

The Safe Motherhood Project had several objectives formulated using the RE-AIM framework. This framework is designed to support evaluation of the public health impact of interventions by examining intervention reach (R), efficacy (E), adoption (A), implementation (I) and maintenance (M) of the intervention.⁽¹⁾ Although four interventions (MWHs⁺, local leader training, health extension practitioner¹ training, and mobile health interventions for health extension worker (HEW) and midwife communication) were planned, the project ended up focusing on MWHs⁺ and training of local leaders using information, education and communication (IEC) materials developed.

The project involved designing both intervention components and collecting baseline and endline data to assess the effect of the interventions: (i) on maternal healthcare service coverage (reach and efficacy), (ii) changes in the knowledge, attitudes and practices related to maternal healthcare services of HEWs, women, men and leaders and (iii) the level of uptake of the MWHs⁺ intervention and IEC materials by the Jimma Zone Health Office including changes in policy and resource allocation (adoption). The strategies used by the community and zonal administration to maintain MWHs⁺ was also a project objective (maintenance). Project monitoring and evaluation data was collected periodically as part of implementation oversight. The project included collection of both qualitative and quantitative data and employed cluster-randomized controlled trial design to evaluate intervention effects.

I focused my third thesis research objective on answering the Safe Motherhood Project's research question about the effectiveness of MWH⁺ and training of local leaders in increasing the proportion of women who give birth at a health facility (use of delivery care services).

A1.2. Overview of the local leader training intervention component

HEWs hold positions of trust as community-based health leaders and have the potential to influence utilization of maternal healthcare services in Ethiopia. To leverage this, the local leader training component of the interventions involved HEWs as training workshop co-facilitators. The

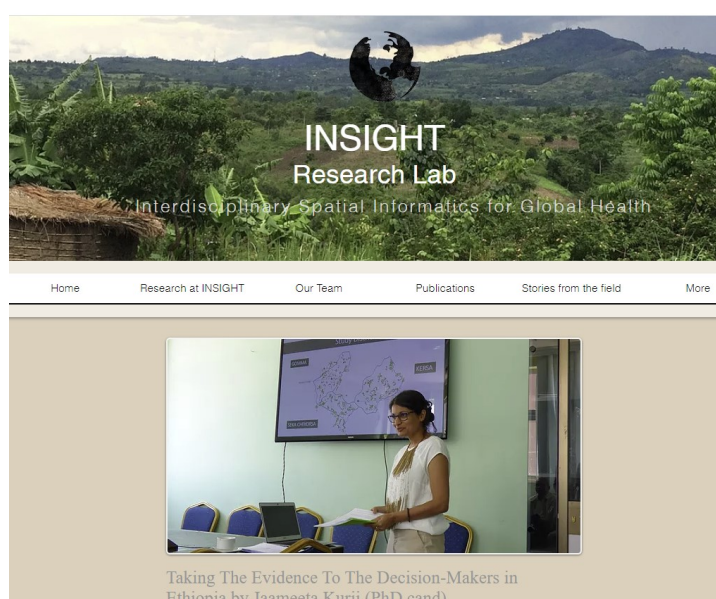
¹ Health extension practitioners are HEWs that have at least two years of service who then receive an additional two years of training to enhance their service capacity.⁽⁸⁴⁾

workshops targeted Women Development Army (WDA) volunteers who routinely work closely with HEWs and also have extensive reach in the communities. The workshops also included religious leaders and members of the Men's Development Army. Being community members themselves, the involvement of all these leaders in the co-creation of locally-suited solutions to improve women's access to care follows an "empowerment model" of community participation. In this model, community participation is not simply viewed as a means to an end (increased service access) but rather as a process of power redistribution and accumulation of social capital.(2) The main aim of the workshops was to build on shared experiences around successful strategies to mobilize communities to positively support women's access to and use of maternal healthcare services.

A1.3. Information brief prepared for the National Advisory Committee

A national advisory committee (NAC) consisting of members of the Ethiopian Federal Ministry of Health, the Oromia Region Health Bureau and the Jimma Zone Health Office was assembled for the project in early 2016. Other stakeholders on the NAC included representatives from the National Ethics Committee in Ethiopia and the Ethiopian Public Health Institute. The purpose of the NAC was to ensure sustained ownership of the research and to facilitate continual dissemination of research findings to decision makers. The NAC also provided a platform through which stakeholders could provide feedback, monitor implementation and help to contextualize findings.

Meetings with the NAC and the research team were held annually in Addis Ababa. A copy of the information brief that I prepared for the 2017 meeting is included here. An account of the 2019 NAC meeting can be found at the INSIGHT team's website: <https://www.manishakulkarni.com/taking-the-evidence-to-decision-makers>



Jimma IMCHA Trial: Baseline Survey Findings

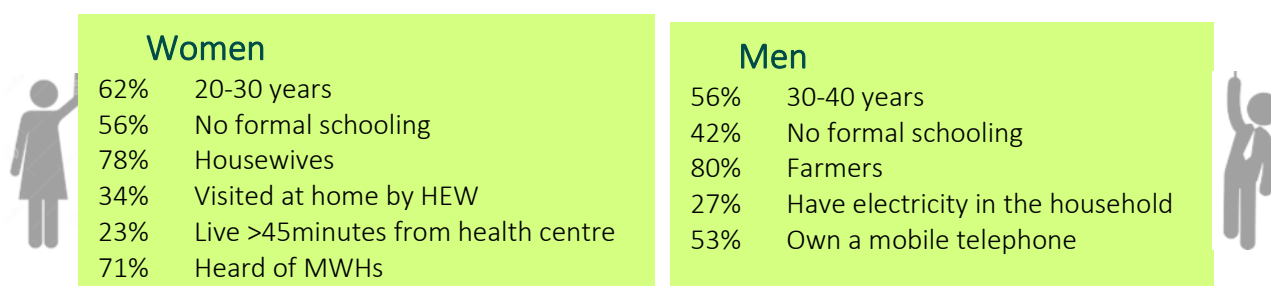
Jimma University, University of Ottawa & Jimma Zone Health Office

About the Study

As part of an implementation study of interventions to promote safe motherhood in Jimma Zone, a baseline survey was conducted to understand women's utilization of maternal health services during pregnancy and childbirth, and after delivery. Twenty-four health centres in Gomma, Seka Chekorsa and Kersa districts were selected to participate in the cluster-randomized controlled trial to evaluate the effectiveness of functional maternity waiting homes (MWHs) and religious and community leader training in improving institutional birth rates. 160 women who had a pregnancy outcome up to a year before the baseline survey were randomly selected from within the catchment areas of these health centres.

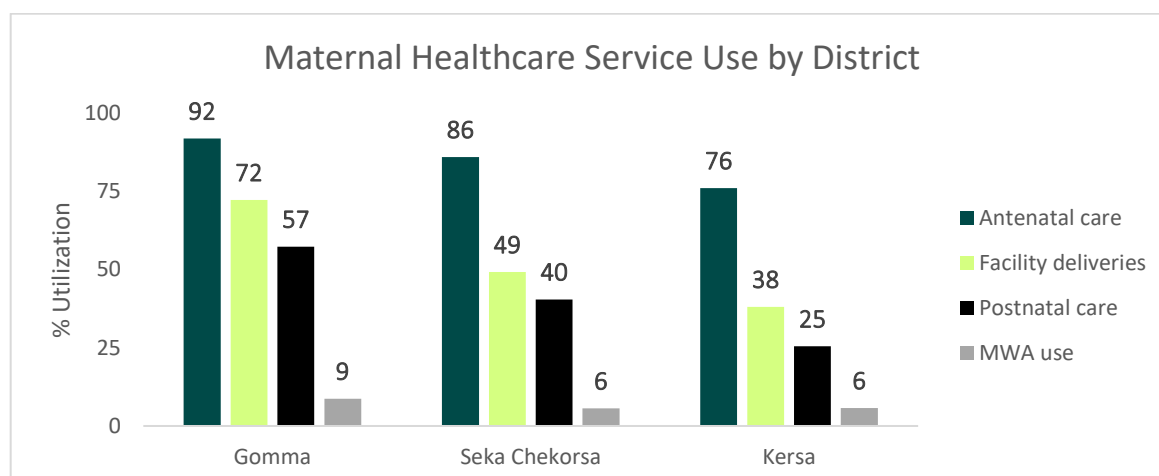
Participant Profiles

3,784 eligible women (98%) were successfully interviewed during the baseline survey that took place between October 2016 and January 2017. 85% of husbands were also available and interviewed.

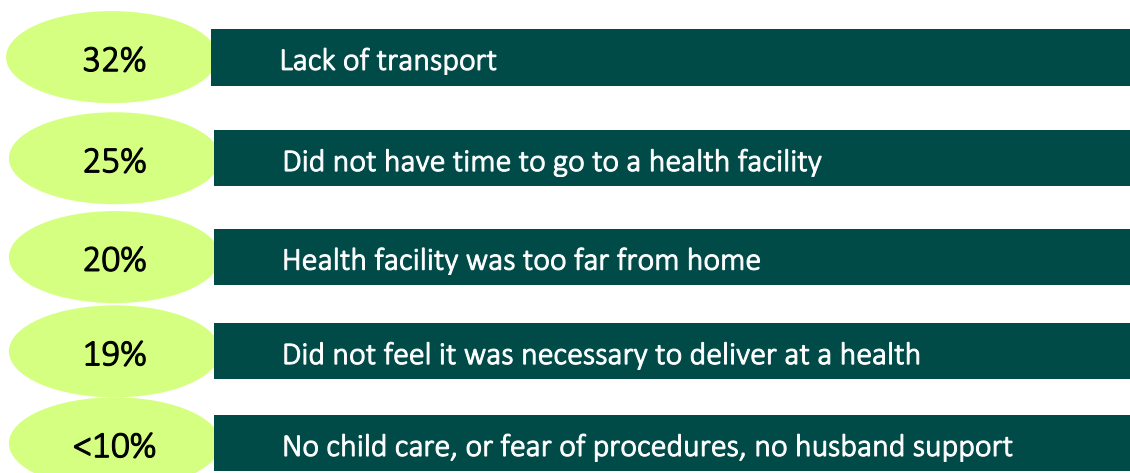


Baseline Service Coverage Levels

The study's safe motherhood interventions aim to improve coverage of maternal healthcare services by improving the quality of MWHs and creating an enabling environment for women through enhanced community awareness and support of these services. Baseline levels of service use were, therefore, assessed prior to intervention roll-out.



Reasons for Not Delivering at a Health Facility*



*Multiple responses were possible

What's Next for the Study?



Intervention roll-out began shortly after the baseline survey was completed with all participating PHCUs receiving MWH supplies during May 2017. **137** health extension workers and **123** religious have been trained to date. Close to **10,000** Development Army members will be trained by the end of 2017.



The **Endline Survey** is tentatively set to begin in September 2018. 3,840 women and husbands will be recruited and interviewed. Intervention effectiveness analysis will involve an evaluation of the change in institutional birth coverage between the survey periods.

Study Team



Jimma University: Lakew Gebretsadik, Sudhakar Morankar, Muluemebet Wordofa, Getachew Kiros, Shifera Asfaw, Abebe Mamo, Yisalemush Asefa, Gemechu Beyene
University of Ottawa: Ronald Labonté, Manisha Kulkarni, Jaameeta Kurji, Nicole Bergen, Corinne Packer
Jimma Zone Health Office: Kunuz Haji, Gebeyehu Bulcha

Funding

This work was carried out with grants #108028-001 (Jimma University) and #108028-002 (University of Ottawa) from the Innovating for Maternal and Child Health in Africa initiative (co-funded by Global Affairs Canada (GAC), the Canadian Institutes of Health Research (CIHR) and Canada's International Development Research Centre (IDRC)); it does not necessarily reflect the opinions of these organizations.

Chapter 2. Background

A2.1. Signal functions used to assess emergency obstetric care (EmOC) capacity

Table A 2.1.1. Signal functions used to assess EmOC capacity (by major obstetric complication)

Signal function	Major obstetric complication						
	Haemorrhage	Obstructed labour	Sepsis	Abortion complication	Pre-/eclampsia	Ectopic pregnancy	Ruptured uterus
Basic services (BEmOC)							
Antibiotics			+	+			+
Uterotonics	+	+					
Anticonvulsants					+		
Placenta removal	+						
Retained product removal	+		+	+			
Assisted vaginal delivery		+					
Neonatal resuscitation							
Comprehensive services (CEmOC)							
Surgery (ex: caesarean section)	+	+	+	+	+	+	+
Blood transfusions	+			+		+	+

Source: UNFPA/WHO Handbook for monitoring EmOC (2009)(3)

A2.2. Photographs² of delivery rooms and postnatal wards at selected study sites

Most labour rooms had two birth couches that were well-worn and often had stirrups to secure women's legs. Labour rooms varied in their cleanliness and tidiness. The availability of clean running water and soap as well as a light source also varied between sites. None of the rooms had any curtains for privacy to separating women or room to accommodate companions. Some labour wards had clearly marked buckets for waste and soiled material management.



Gembe health centre, Gomma district
(December, 2015)



Bulbul health centre, Kersa district (July, 2017)



Waste management at Kara Gora health centre labour room, Kersa district (July 2017)



Postnatal ward Bulbul health centre, Kersa
Kersa district (July 2017)

² I took all the photographs included in the thesis during several field visits over the study duration

A2.3. Quality of evidence on factors associated with ANC use in Ethiopia

With respect to methodological quality, Tekelab et al. rated most of the primary studies included in their review as high.⁽⁴⁾ However, closer inspection of the original studies exposed several issues that need to be noted when considering available evidence on factors that are associated with ANC use in Ethiopia. Using the Newcastle-Ottawa quality assessment scale³, the reviewers awarded three or more stars to selection processes in 12 included studies, suggesting they found very little amiss in these studies; however, examination of the individual studies revealed little or no information on sampling frame (5–11), participant recruitment procedures or the number of eligible participants approached (5,7,10,12,13) in these studies, which makes it difficult to rule out the presence of selection bias or verify how representative the included samples were. The review authors also generally rated included studies high on “exposure ascertainment”, which presumably pertained to how independent variables of interest were determined. However, 12 primary studies either did not provide variable definitions or had details missing such as what information the variable represented and/or how responses were categorized.^(5–8,10–17) In many cases, this made it difficult to discern what precisely the outcome was associated with, making comparisons between studies tenuous. For example, Tekelab and colleagues reported the pooled estimate as comparing ANC use among educated and non-educated women. However, the primary studies differed in their definitions of education with three studies combining education level and literacy and using non-literate as the reference group (5,12,16) while the rest focused solely on level of schooling completed. Unclear and incomplete study definitions can also lead to misclassification and, therefore, the presence of information bias cannot be dismissed.⁽¹⁸⁾

Several of the primary studies in the Tekelab et al. review also used statistical significance in bivariable analyses to determine what factors to include in multivariable analyses used to generate associations.^(6,7,13,15,16) A few studies (14,16) modelled groups of factors such as socio-demographics (e.g., education or household wealth) separately from other groups such as reproductive history (e.g., parity, prior pregnancy complications, history of stillbirths) which could result in higher residual confounding in each model than may have been obtained from modelling all relevant factors together.

Several primary studies also used multi-stage sampling strategies (5–10,12–17,19), but only one study described accounting for clustering in their analysis.⁽⁷⁾ Other modelling concerns included the

³ The Newcastle-Ottawa quality assessment scale is designed to assess the quality of case control and cohort studies. It includes ratings for selection (representativeness and selection methods, maximum 4 stars), comparability (of groups being compared, maximum 2 stars) and methods of ascertaining exposure/outcome (how each were determined, if methods used for two groups were comparable and if non-response was reported, maximum 3 stars). The review authors reported star ratings for selection, comparability and outcome assessment, but did not provide any information about how these ratings were arrived at or what issues were identified in relation to the original studies.

categorization of responses that resulted in very small cell frequencies or no observations for some response-outcome combinations (5,7,8,10,12,14,16,17,19), which would affect model stability and parameter estimate credibility.(20) Standard errors will also be inflated when there is collinearity between explanatory variables included in a model.(21) The possibility of correlation between some independent variables included in multivariable models (such as age and parity, travel duration and mode of transport, or history of pregnancy complications and prior service use) may also affect parameter stability.

A2.4. Quality of evidence on factors associated with delivery care use in Ethiopia

A2.4.1 Review by Nigusie et al.(22)

While the above review highlights potential factors that may influence delivery care use in Ethiopia, the estimates reported have to be viewed with caution. The review authors neither provided descriptions for variables nor explained what response options from original studies they encompassed; they also did not describe how variables had been further categorized, all of which made findings hard to interpret. In fact, several primary studies themselves did not report how variables were assessed or responses classified (23–34) which severely limited comparability and increased the chances of misclassification and information bias. An example of this issue could be seen with the variable “maternal knowledge” which was described by the review authors as awareness about pregnancy-related danger signs and benefits of institutional delivery services. Of the 11 primary studies used to generate a summary pooled odds ratio by the review authors, one study reported on awareness of “pregnancy complications”(31), three reported on danger signs during labour (25,29,35), three combined awareness of pregnancy, labour and /or postpartum danger signs (27,36,37), one reported pregnancy, labour and postpartum danger signs separately(33), one considered knowledge as “awareness about pregnancy and delivery complications, importance of delivery care, availability of ambulance services and risks of complications”(32), another study reported on both awareness of delivery services as well as perceived benefits of institutional delivery (28) while yet another focused on awareness of ANC and delivery service availability.(34) Primary studies also varied on their definition of what constituted adequate awareness with some using a 50% cut-off for their score (27) while others used sample means as cut-offs (36,37); however, most provided no information about how they categorized responses.(25,26,29,31–35) Given the variability in what each variable represented, the use of arbitrary cut-offs that were likely to be context-dependent and the breadth of constructs included under “maternal knowledge”, how meaningful a pooled estimate is, is uncertain. Nevertheless, it does point to a potential correlation between awareness of complications during pregnancy and delivery on use of delivery care which should be investigated appropriately.

The reference group against which comparisons were made were also not always reported by the Nigusie et al. For instance, it is unclear what the reference group was for travel time and information source availability were. The review authors also described using adjusted estimates from individual studies to generate pooled estimates. However, it is unclear how this was possible for occupation, travel time, information source and knowledge as some of the relevant original studies included either did not present adjusted estimates for the candidate factor under question (24,28,30,34) or used different categories from those included in the meta-analysis (33), meaning the review authors presumably pooled raw counts rather than adjusted estimates.

The review authors also rated all the included studies as being high quality. However, most of the included primary studies had inadequate levels of reporting on selection and recruitment of women (23–25,27,30–32,35,36,38) making it difficult to rule out the presence of selection bias. Moreover, very few studies provided information about the sampling frame used and did not comment on how complete or up to date it was.(25,28,31,33,34,39,40) Some studies reported using HEWs or nurses as data collectors (39) which may have influenced women's responses particularly around health-system related barriers to accessing delivery care. The lack of clarity around variable definitions and ascertainment of “exposures” of interest means that the extent of misclassification cannot be assessed; the presence information bias, thus, cannot be dismissed.(18)

In terms of analysis, the majority of included studies did not adjust for clustering in regression models despite using multi-level sampling.(23–26,28,30–40) In spite of the increased likelihood of excluding important confounders and introducing noise variables into regression models associated with p-value based variable selection methods (21), many primary studies adopted this approach to decide on which variables to include in their multivariable models.(23–25,27,28,30,32–36,38–40) Model parsimony is also not usually as much of a priority in exploratory models as it is in prediction models thus making these variable selection methods difficult to justify.(21) Several studies also had small cell frequencies (< 10 observations) (23,24,26,28–33,35–37,40) which can lead to sparse data problems; some studies included independent variables that may have been correlated with each other such as age and parity (36,38), gravidity and parity (29) or ANC use and frequency of ANC use.(32) Some primary studies modelled groups of factors separately (23,32,36) rather than combining all relevant factors together which would likely have lower residual confounding.

A2.4.2 Review by Kebede et al. (41)

While a random-effects model was used to generate pooled estimates in this meta-analysis, it is unclear whether the authors used adjusted estimates or not. The primary studies included in the systematic review were mostly cross-sectional in nature and although rated fairly highly in terms of

quality by the review authors, suffered from several issues discussed in previous sections. Very few studies reported sufficient details on participant selection and recruitment, completeness of sampling frames and whether or not efforts were made to reach selected women who were unavailable when data collectors first visited homes.(11,31,42–46) Also, while several described randomly selecting women, no information was provided on how exactly this was done. It is difficult, therefore, to exclude the possibility of selection bias which can be present as a result of systematic errors in participant selection and recruitment.(18) It may also have implications for the external validity of the findings.

The review authors described assessing the quality of included studies but did not report any details. An examination of the original studies included in the review also revealed several errors in the review such as including a primary study conducted in Pakistan (47), a qualitative study from Indonesia(48) and one which analysed DHS data on six countries that did not include Ethiopia.(49) Kebede et al. also reported using data from a meta-analysis on delivery care and neonatal mortality, but that meta-analysis did not appear to report any results on any factors listed nor was it restricted to studies conducted in Ethiopia.(50) There were also studies duplicated within models using inconsistent data which further compromised the reported pooled estimates.

While I surveyed the review by Kebede and colleagues to get a general sense of factors that may influence delivery care use in Ethiopia, the pooled effect estimates have largely been disregarded when considering available evidence. Moreover, many of the original included studies also suffered from methodological issues described earlier which may also compromise their validity and thus, that of the meta-analysis. The presence of publication bias in the systematic review was also not assessed. Neither the search strategy nor the list of included studies was available making it difficult to judge the extent to which all eligible studies were captured.

A2.5. Quality of evidence on factors associated with PNC use in Ethiopia

Most primary studies included in the review by Chaka et al. (51) did not provide clear descriptions of candidate correlates or had very unclear ones. Decision-making was one example where one primary study hinted at it representing women's involvement in decisions around healthcare spending (46) while another seemed to be evaluating women's involvement in decisions to use health services.(45) A pooled estimate was, nevertheless, generated by the review authors. Two additional primary studies included in the review that investigated decision-making involvement were neither included in the meta-analysis pooled estimate nor discussed. Both studies did not report a significant association between women's involvement in decisions (dimension unspecified) (17) or decisions about healthcare spending.(15) The absence of clearly defined variables considered as potential correlates of PNC use means that information bias due to potential misclassification of "exposure" groups (i.e. candidate correlates of

PNC use) is also possible. This can also result in residual confounding due to improper adjustment for potential explanatory factors (18) and reduces comparability between studies difficult while also making interpretation of pooled estimates uncertain.

The review authors also generated a pooled estimate that combined both distance (46) and travel time (44,45) using three studies. Two of the studies pointed towards shorter distance and travel times favouring PNC use (44,46) while one was inconclusive (45) underscoring the need for well-defined, reliable metrics to be used to assess the association between service use and physical barriers such as distance.

The lack of information about variables also made it difficult to understand the rationale behind choices review authors made in which primary studies to include in the meta-analysis. For example, for women's and husband's education the review authors left out two studies (11,17) that reported seemingly comparable variables. Two other studies may have been excluded as they combined literacy and education into one variable.(31,42) There was no clear trend in the associations reported by individual studies not included in the meta-analysis; three reported no effect (11,31,42) and one had an inverse association with higher education resulting in lower odds of PNC use.(17)

A2.6. Photographs of selected MWHs within the study districts

(All photographs included were taken by me during field visits to Ethiopia between 2015 and 2019)

Sleeping spaces at MWHs without any upgrades



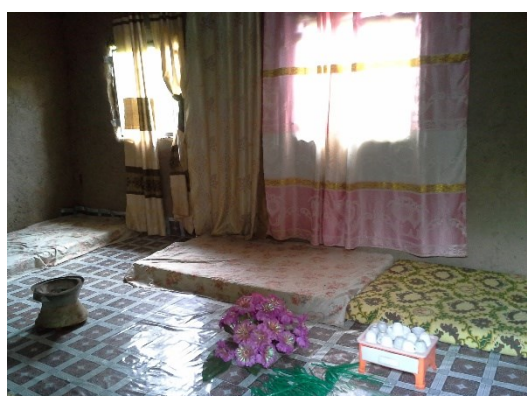
Serbo, Kersa District
(December 2015)



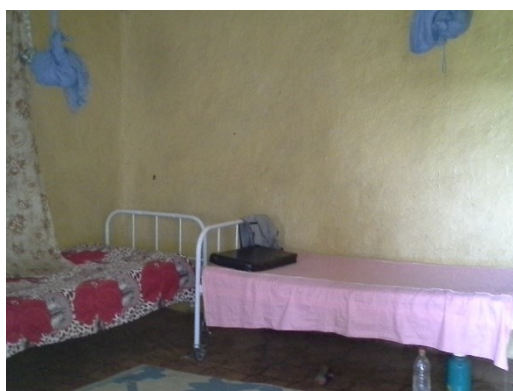
Bula Wajo, Kersa District
(May 2016)



Gembe, Gomma District
(December, 2015)



Seka, Seka Chekorsa District
(July, 2017)



Choche, Gomma District
(May, 2016)



Detu Kersu,
Seka
(July, 2017)



Buyo Kechama,
Seka Chekorsa
(July, 2017)

Water storage



Limu Shayi, Gomma district (May, 2016)

Latrines



Bula Wajo, Kersa District
(May 2016)



Detu Kersu, Seka Chekorsa District
(July, 2017)

Cooking spaces



Kellacha, Kersa District
(July, 2017)



Choche, Gomma District
(May, 2016)

A2.7. Correlations of MWHs with mortality and health outcomes

To explore the impact of MWHs on maternal health, several studies have compared the proportion of obstetric complications between MWH users and non-users. In general, the proportion of women with complications is reported by available studies to be lower among MWH users than non-users. Uterine rupture⁴, for instance, was uncommon among users but ranged from 2% to 7% among non-users (52–54) apart from one study which recorded no cases.(55) Prolonged labour and premature rupture of membranes, reported by two studies in Ethiopia (54,56) and an earlier Zimbabwean study (55), were generally higher among non-users than users. Record reviews at 3,804 facilities in Ethiopia offering obstetric care compared facility-level rates of direct complications per 100 deliveries. While health centres with MWHs did not have significantly different direct obstetric complication rates, complication rates were 47% lower in hospitals with MWHs than those without.(57) It is important to note that individual-woman data was not available and, therefore, findings do not distinguish between users and non-users. Aggregated, retrospective routinely collected data was also used in this analysis.(57)

Studies reporting comparative percentages of maternal death between MWH users and non-users are available from rural Ethiopia (52–54,58,59), Eritrea (60) and Zimbabwe.(55,61,62) Most studies recorded no difference in proportion of deaths, while three registered slightly higher levels among non-users. Several of the studies had small sample sizes that were probably unlikely to be able to detect changes in this rare outcome. A study in Liberia, comparing maternal deaths using facility data, reported statistically significant lower deaths among communities with than without MWHs (Wald $\chi^2 = 4.22$, $p=0.04$). (63)

With respect to correlations between MWH use and newborn mortality, studies from Ethiopia (52–54,56,58,59) Eritrea (60) and Zimbabwe (55,61,64) have reported differences in percentages of stillbirths or perinatal mortality between users and non-users. In general, a higher proportion of stillbirths was noted among non-users than MWH users.(52–54,58,61,64,65) However, studies from Zimbabwe and Liberia found no statistical difference in levels of perinatal deaths between users and non-users.(61,63–65) When perinatal death rates in Ethiopia were compared by type of facility no significant differences were detected between health centres with or without MWHs; but, perinatal death rates were 47% lower among hospitals with MWHs than those without. These results were obtained when region, managing authority, location (rural/urban), capacity and readiness to provide

⁴ Uterine rupture is the “catastrophic tearing of the uterus into the abdominal cavity”.(85) Women with prior caesarean sections are typically at risk for uterine rupture. Analysis on data from 29 countries found that 1% of women in developing countries with prior caesarean section suffered uterine rupture. Risk factors include lower education, spontaneous onset of labour and preterm births. Maternal deaths and perinatal death are higher among women with uterine rupture.(86)

EmOC, delivery volume, skilled birth attendant densities and availability of motor vehicle transport at the facilities were included in the model.(57) In Ethiopia, Braat et al. reported lower odds of stillbirths among MWH users compared to non-users (crude OR = 0.18; 95% CI 0.13 to 0.25) as well as women from a different health facility with no MWH present (crude OR = 0.17; 95% CI 0.12 to 0.24).(59)

A recently published meta-analysis attempted to quantify the effect of MWH use on perinatal mortality in Ethiopia; the authors concluded that MWHs reduced perinatal mortality by over 80% (pooled OR = 0.15; 95% CI: 0.14 to 0.17; 10 observational studies) and should be incorporated into routine maternal healthcare services.(66) However, there were several methodological issues which limited the reliability the findings which are discussed at length in Appendix 2.8. There were outcome abstraction errors, several eligible studies were missing, the search strategy used was not reported and, strong causal conclusions made using unadjusted estimates from observational studies which are likely to have selection bias and confounding.(67,68) Moreover, the authors used a fixed effect model to generate pooled estimates which is likely inappropriate for complex public health interventions.(69–72) This is because these interventions tend to have considerable heterogeneity in user characteristics, intervention implementation and contextual influences as has been demonstrated for MWHs.(73) Aside from this, it is difficult to confidently attribute any reductions in perinatal mortality to MWH use without a better understanding of modifiable risk factors that are associated with use. For instance, reporting the type of stillbirth (intrapartum or antepartum) could help to disentangle stillbirths that may be averted through timely access to obstetric care from those caused by more long-term issues such as foetal growth restriction (74) which MWH stay would not have any influence over.

A2.8. Critique on meta-analysis of the effect of MWH use on perinatal mortality in Africa

A re-print of the published critique is included here under the Creative Commons Attribution 4.0 International License which allows unrestricted use, distribution and reproduction in any medium. The link to the Creative Commons License is: <http://creativecommons.org/licenses/by/4.0/>

Article citation

Kurji, J., Hackett, K, Wild, K et al. The effect of maternity waiting homes on perinatal mortality is inconclusive: a critical appraisal of existing evidence from Sub-Saharan Africa. BMC Res Notes (2021) 14:86. <https://doi.org/10.1186/s13104-021-05501-2>

The re-print is included between thesis pages 288-296.



The effect of maternity waiting homes on perinatal mortality is inconclusive: a critical appraisal of existing evidence from Sub-Saharan Africa

Jaameeta Kurji¹, Kristy Hackett², Kayli Wild³ and Zohra Lassi^{4*} 

Abstract

Objectives: To assess the appropriateness of the statistical methodology used in a recent meta-analysis investigating the effect of maternity waiting homes (MWHs) on perinatal mortality in Sub-Saharan Africa.

Results: A recent meta-analysis published in BMC Research Notes used a fixed-effect model to generate an unadjusted summary estimate of the effectiveness of MWHs in reducing perinatal mortality in Africa using ten observational studies (pooled odds ratio 0.15, 95% confidence interval 0.14–0.17). The authors concluded that MWHs reduce perinatal mortality by over 80% and should be incorporated into routine maternal health care services. In the present article, we illustrate that due to the contextual and methodological heterogeneity present in existing studies, the authors' conclusions about the effectiveness of MWHs in reducing perinatal mortality were likely overstated. Additionally, we argue that because of the selection bias and confounding inherent in observational studies, unadjusted pooled estimates provide little causal evidence for effectiveness. Additional studies with robust designs are required before an appropriately designed meta-analysis can be conducted; until then, the ability to draw causal inferences regarding the effectiveness of MWHs in reducing perinatal mortality is limited.

Keywords: Maternity waiting homes, Perinatal mortality, Stillbirths, Meta-analysis, Sub-Saharan Africa, Heterogeneity, Observational studies, Random-effects models

Introduction

There is renewed interest in maternity waiting homes (MWHs) as a strategy to increase facility-based obstetric care and reduce maternal and perinatal mortality. MWHs provide temporary accommodation near a health facility prior to birth for women with high-risk pregnancies and/or living far away from health facilities [1]. Several African and Asian countries are investing in MWH scale-up as part of their national health strategies [2–5].

While observational studies have reported some benefits [6–8] there is still insufficient evidence that MWHs reduce mortality [3, 9] or impact newborn outcomes [10]. The quality of available evidence is also low, yet a recently published meta-analysis has drawn strong conclusions in favour of MWHs. An 82.5% reduction in perinatal mortality was attributed to MWH use and consequently, the authors recommend that “all pregnant women be admitted to MWHs before delivery” [11]. This review has been cited repeatedly to advocate MWH use [12–19] despite limitations in the original studies and the review. In this research note, we critically assess the analytic approach employed in this meta-analysis [11] and discuss

*Correspondence: 

⁴ Robinson Research Institute, Adelaide Medical School, The University of Adelaide, Helen Mayo North, 30 Frome Street, Adelaide, Australia
Full list of author information is available at the end of the article



© The Author(s) 2021. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

important considerations when pooling observational data on complex interventions such as MWHs.

Main text

Features of the recent meta-analysis on MWHs and perinatal mortality

The meta-analysis by Bekele and colleagues included ten observational studies from six countries [7, 8, 20–27] after 31% ($n=73/236$) were excluded because full texts were unavailable [11]. Most of these studies included women who delivered at hospitals offering some level of comprehensive emergency obstetric care [7, 8, 20, 21, 23, 26, 27]. The number of perinatal deaths abstracted for MWH users and women admitted directly to hospitals were reported [11], but there were abstraction errors for two studies [21, 27] and some overlap in data from two studies conducted at Attat Hospital in Ethiopia [8, 24]. Three studies [7, 8, 23] reported stillbirths but not early neonatal deaths and in two others it was difficult to distinguish outcomes for MWH users and non-users [22, 26]. The authors used a fixed-effect model to generate an unadjusted pooled odds ratio estimating the association between MWH use and perinatal mortality. The authors reported conducting sub-group analyses by study design due to the high degree of heterogeneity detected ($I^2=97\%$), but no sub-group estimates were reported or discussed [11].

Methodological considerations

Choice of model for meta-analysis of complex interventions

Decisions about which statistical model to use in a meta-analysis depends on the type of effect expected and the goal of the analysis [28]. Using a fixed-effect model conveys the belief that there is one common true effect size estimated by all individual studies, and that differences in observed effect sizes are a result of sampling error [28–30]. When a fixed-effect model is used, the goal is not to extrapolate findings beyond the included set of studies [28, 31]. In contrast, random-effects models are suitable when a distribution of true effects exists, and included studies represent a random sample of possibilities; in this case, findings may be generalized to other similar scenarios [29].

Heterogeneity is the variability in true effects underlying different studies [32, 33]. The I^2 statistic (indicates the proportion of variance in observed effects due to variance in true effects and is a “measure of inconsistency”) [32, 33] is often used to decide whether sufficient heterogeneity exists to run a random-effects model but this is not recommended as it has low power [28]. What may be more useful is to assess whether it is likely that studies included are “functionally identical” [29] as assumed under a fixed-effect model. Widespread differences in

participant characteristics, intervention designs, settings and outcomes, make the absence of heterogeneity unlikely [28, 33, 34]. Public health interventions are even less likely to be homogenous; they often have interacting components targeting multiple groups, accommodate flexible delivery, and are embedded within complex systems [35]. Given the considerable variation in MWH implementation [36] random-effects models are likely more suitable for meta-analyses involving MWHs.

Alone, however, the estimated mean effect provides an incomplete picture [37] as how effect sizes vary under different conditions and populations is often of interest [38]. With sufficient numbers of studies, sub-group analysis within a few important, pre-specified subgroups (to avoid issues with multiple testing) [28, 39] is one way to explore heterogeneity. Results need to be interpreted cautiously due to the observational nature of the analysis [30].

Finally, in fixed-effect models, larger studies are weighted more heavily [30] as they have smaller sampling error and higher precision. The pooled estimate reported by Bekele et al. [11] was, thus, largely influenced by one study [8] (weight: ~74%). In random-effects models, each study provides unique information about the distribution of true effect sizes, therefore weighting is more equivalent [29].

Methodology for the present study

In light of the methodological considerations outlined above, we sought to critically assess the methodology employed by Bekele and colleagues, and explore whether heterogeneity may be better accounted for using a random-effects model. For illustrative purposes, we re-abstracted information from the seven studies [7, 8, 20, 21, 23, 25, 27] from the review that had appropriate data available, as well as three additional eligible studies [40–42] identified from reference lists (Table 1). We calculated a summary estimate in Review Manager version 5.4 using a random-effects model for stillbirths and perinatal mortality separately, using unadjusted outcome events reported for MWH users and women directly admitted to hospital.

To explore heterogeneity, we conducted sub-group analysis for stillbirths to demonstrate how country and type of managing authority may change effect estimates. While no definitive conclusions can be made, the results provide insight into sources of heterogeneity.

Random effects model findings and implications

The pooled estimates are suggestive of an association between MWH use and lower stillbirths (pooled Risk Ratio [RR] = 0.39, 95% Confidence Interval [CI]: 0.19 to 0.80; nine studies; 43,385 participants) and to a lesser

Table 1 Summary of characteristics of the eleven studies included in the present study

Author (year)	Country	Design and data sources	Facility level, location, obstetric care and managing authority	Type of comparison group	MWH admission criteria and (% MWH use)	Community outreach	Health worker monitoring of users	Study quality ^d
Braat et al (2018)	Ethiopia	Hospital-based retrospective cohort. Hospital records and hospital-based survey	Rural NGO hospital providing CEmOC	Direct admissions ^{a,b}	Risk factors, distance (34%)	Well established program set up by Attat hospital	None at MWH, users expected to attend routine ANC clinic at hospital	Selection bias possibly present. No adjustment for confounders. Sample size adequacy uncertain. Findings limited to women using hospital-level care
Chandramohan et al. (1995)	Zimbabwe	Hospital based cohort. Labour ward logbook	Rural government referral hospital with doctors on staff to handle complicated births	Direct admissions	Focus on risk factors, but any pregnant woman permitted to stay (35%)	No information	Weekly examination by midwife at MWH	Sample size adequacy uncertain. Findings limited to women using hospital-level care
Fogliati et al. (2017)	Tanzania	Cross-sectional hospital study. Survey and patient records	Rural NGO hospital providing CEmOC	Direct admissions	No information (31%)	No information	No information	No adjustment for confounders. Sample size adequacy uncertain. Uncertainty around comparability of risk profile between groups
Kelly et al. (2010)	Ethiopia	Hospital-based retrospective cohort. Delivery records	Rural NGO hospital providing CEmOC	Direct admissions	Risk factors (average: 28%, range 25%-56%)	Hospital program to train TBAs and CHWs to identify and refer pregnant women	None at MWH, users expected to attend routine ANC clinic at hospital	Descriptive comparison of perinatal outcomes. Uncertainty around comparability of groups. No information on data source completeness
Gaym et al. (2012) ^b	Ethiopia	Hospital-based retrospective cohort. No information	Rural NGO hospital, no information on obstetric care capacity	Direct admissions	No information (10%)	No information	No information	Descriptive comparison of perinatal outcomes between users and non-users that was not the primary aim. Selection bias, sample size adequacy and group comparability all uncertain

Table 1 (continued)

Author (year)	Country	Design and data sources	Facility level, location, obstetric care and managing authority	Type of comparison group	MWH admission criteria and (% MWH use)	Community outreach	Health worker monitoring of users	Study quality ^d
Mesheha et al. (2017)	Ethiopia	Hospital-based study with unclear design. Delivery records	Rural government general hospital. No information about obstetric care capacity	Direct admissions	No information (17%)	No information	No information	Descriptive results limited to women able to access facility-based obstetric care. Inadequate reporting makes it difficult to assess the extent of misclassification bias and selection bias
Millard et al. (1991)	Zimbabwe	Hospital-based retrospective cohort. Hospital records	Rural NGO hospital with C-section services	Direct admissions	Focus on risk factors and distance, but any pregnant woman permitted to stay (60%)	No information	No information	Older study with inadequate reporting presenting descriptive results of hospital-based sample. Comparability of group risk profile uncertain
Singh et al. (2016)	Malawi	Hospital-based cross-sectional study. Interviews and intake/discharge forms	2 sites—rural government hospital and urban health centre. No information on obstetric care capacity	Direct admissions	Focus on risk factors and distance, but any pregnant woman permitted to stay (N/A)	Safe Motherhood project in study district includes community education to increase use of services including MWHs	No information	Descriptive results limited to women able to access facility-based obstetric care. Inadequate reporting makes it difficult to assess the extent of misclassification bias and selection bias
Turnwine et al. (1996)	Zimbabwe	Hospital-based retrospective cohort. No information	Rural NGO hospital with C-section services	Direct admissions	No information (27%)	No information	Unclear	Older study with inadequate reporting presenting descriptive results of hospital-based sample. Comparability of group risk profile uncertain

Table 1 (continued)

Author (year)	Country	Design and data sources	Facility level, location, obstetric care and managing authority	Type of comparison group	MWH admission criteria and (% MWH use)	Community outreach	Health worker monitoring of users	Study quality ^d
van Lonkhuijzen et al. (2003)	Zambia	Hospital-based retrospective cohort. Surveys	Rural NGO hospital with C-section services	Direct admissions	No information	No information	None at MWH, users expected to attend routine ANC clinic at hospital	Descriptive results limited to women able to access facility-based obstetric care. Inadequate reporting makes it difficult to assess the extent of misclassification bias and selection bias

CHW community health worker, C-section Caesarean section, NGO non-governmental organization, TBA traditional birth attendant

^a Direct admission constitute women who delivered at the health facility but did not stay at the MWH prior to delivery

^b Braat et al. had two types of comparison groups – direct admissions from Attat hospital and outcomes from women at Butajira hospital that did not have an MWH. Data used here is for Attat non-users only

^c Perinatal outcomes and MWH use in 2010 reported for Saint Luke's Hospital in Wolisso, South-west Shoa Zone in Oromiya Region

^d The AXIS tool for quality appraisal of cross-sectional studies [46] was used to guide rapid review of study quality

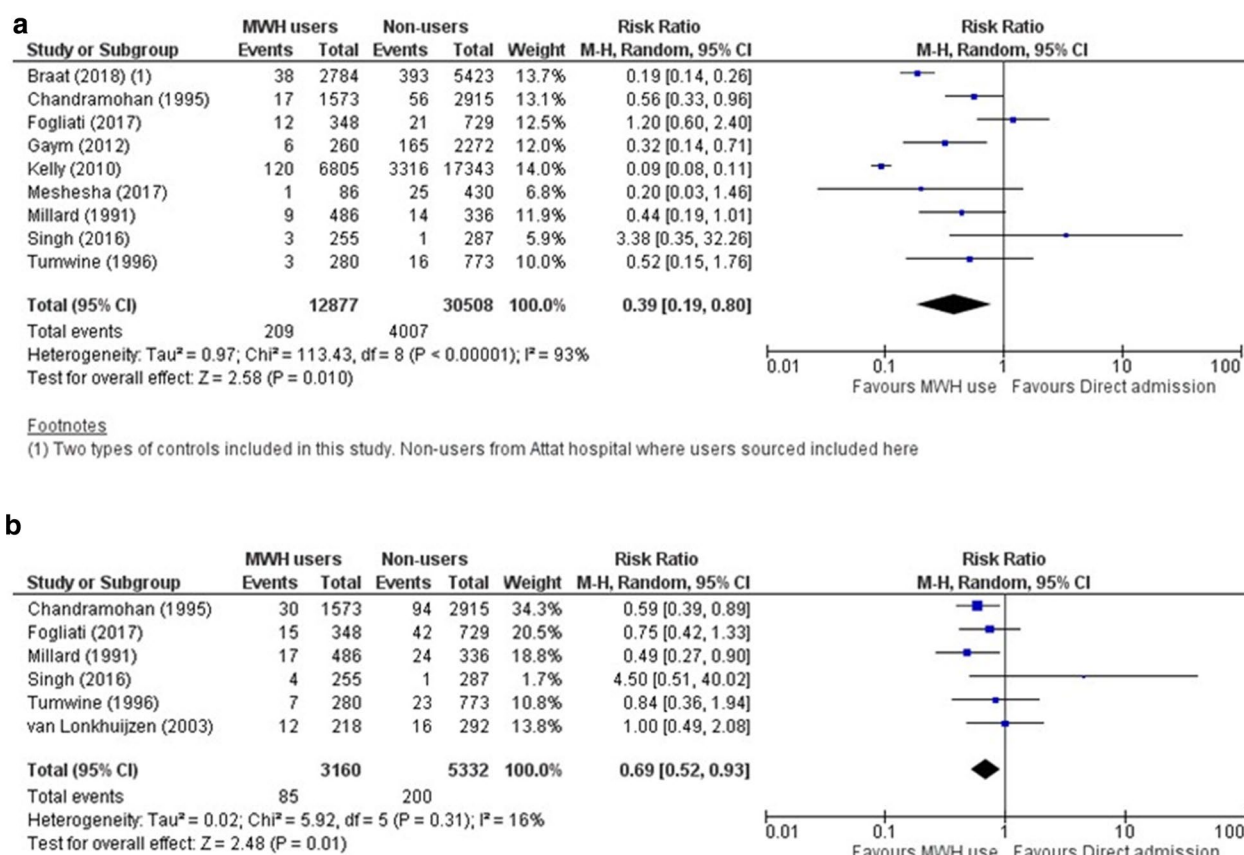


Fig. 1 Forest plots of association between MWH use and (a) stillbirths and (b) perinatal mortality

extent lower perinatal mortality (pooled $RR = 0.69$, 95% CI : 0.52 to 0.93; six studies; 8,492 participants) (Fig. 1). The comparative similarity in weights calculated for stillbirths point to higher between-studies than within-study variance [29]; this is also reflected in the high values of I^2 ($I^2 = 93\%$, indicating 93% of the total variation is attributable to heterogeneity [33]) and τ^2 ($\tau^2 = 0.97$).

The lower I^2 values suggest that there is more consistency among studies conducted in Ethiopia ($I^2 = 86\%$) and even more among those conducted in other countries ($I^2 = 35\%$) than when all studies are considered together ($I^2 = 93\%$) (Table 2).

Overall, the reduction in the between-study variance for country sub-groups ($\tau^2 = 0.10$ —0.28 subgroups versus $\tau^2 = 0.97$ all studies) suggests that between-country contextual differences could be one source of heterogeneity. The between-study variance was also lower when the type of managing authority was considered. There was more consistency among studies

with government-run facilities ($I^2 = 42\%$ $\tau^2 = 0.47$) than overall ($I^2 = 93\%$ $\tau^2 = 0.97$). While the test for subgroup differences was not statistically significant, the existence of heterogeneity due to managing authority cannot be ruled out.

Conclusion

Given the complexity of MWH interventions and the variation in contextual factors, heterogeneity must be appropriately addressed when conducting meta-analysis on MWH effects. More robustly designed studies with adequate reporting are needed to enable exploration of heterogeneity in effects. Careful consideration of the quality of evidence and specific conditions required to improve outcomes for women and babies is required before implementing further scale-up of MWHs.

Table 2 Results of sub-group analyses

Sub-groups		Relative Risk (95% confidence interval)	I ² (%)	τ ²	Number of studies	Number of participants	Test for subgroup differences (p-value)
Country	Ethiopia	0.17 (0.09–0.31)	86	0.28	4	35,403	< 0.001
	Other country	0.70 (0.43–1.14)	35	0.10	5	7982	
Managing authority	Government	0.62 (0.20–1.90)	42	0.47	3	5004	0.34
	Non-government	0.32 (0.15–0.70)	94	0.83	6	37,839	

Limitations

Firstly, meta-analyses produce “observational” results even if randomized controlled-trials (RCTs) are included as random allocation is not preserved [43]. Observational studies, where assignment to comparison groups is not random, are considered to be at even higher risk for selection bias and confounding than RCTs [34]. While a random effects model is more suitable for MWH studies, the pooled estimates presented here may still be compromised by bias and confounding inherent to observational designs. Future analyses may consider meta-regression to assess the effect of study-level covariates on effect sizes [28] when at least ten studies are available [30]. If available, adjusted analyses with comparable adjustment variables can also be used to generate adjusted pooled estimates. Ideally, however, additional individual studies using robust designs are required for results from meta-analyses to be more informative. RCTs are generally accepted as providing the highest quality evidence [34] if well designed, conducted and reported. Where it is not feasible or ethical to conduct trials, longitudinal studies with careful participant selection, adequate confounder information, sufficient follow-up levels that analyse data suitably may be acceptable alternatives. Availability of additional studies would also improve estimates of between-study variance (τ^2) which tend to be imprecise with fewer available studies [28]. Precision, in random effects models, is enhanced by the number of studies included, not study sample sizes [29].

Secondly, while there is an urgent need to improve methodological reporting in primary studies as illustrated in Table 1, there is an equal necessity to provide more details about MWH models themselves. Specifically, information on referral criteria and practices, community outreach activities to raise awareness and facilitate women’s access to MWHs, duration of stay and gestational age at admission, accommodation services available at MWHs, associated costs, level of monitoring of MWHs by health workers, the stage of labour when women are transferred to the health facility, and level of obstetric care available are needed to have a clear understanding of what is required to achieve reported

reductions in mortality. This information could support a more comprehensive exploration of heterogeneity which we were not able to do due to the small number of studies and insufficient reporting in individual studies.

Thirdly, a better understanding of modifiable risk factors associated with stillbirths and neonatal deaths is required to assess the extent to which MWHs could potentially facilitate improved perinatal outcomes. A study investigating modifiable health-system risk factors reported that having to wait more than 10 min to receive care after reaching a facility was associated with higher odds of stillbirth [44]. Other modifiable risk factors for stillbirths include maternal infections and prolonged pregnancy [45] which may be addressed through quality antenatal and intrapartum care, irrespective of MWH use. Reporting the type of stillbirth (intrapartum or antepartum) in future studies may help to disentangle stillbirths that can be averted through access to timely obstetric care (intrapartum stillbirths) and those which result from more long-term issues such as foetal growth restriction [45]. Only one of the studies included in the review made this distinction [21] making it impossible to explore.

Stillbirths and neonatal deaths are also a relatively rare event, which would make it difficult for studies with small sample sizes to detect meaningful changes in outcomes. Any reported associations between MWH use and stillbirth rates or perinatal mortality should, thus, be interpreted with caution.

A defining feature of systematic reviews is the use of clearly articulated, well-documented, comprehensive search strategies targeting multiple sources that are designed to capture the highest proportion of eligible studies in a transparent and reproducible fashion. In this way, bias is minimized and more reliable estimates are generated [30]. Since our aim was to illustrate the issues associated with statistical modelling, we did not repeat the search but largely relied on studies identified by Bekele and colleagues [11].

Finally, no firm conclusions can be drawn about the effectiveness of MWHs in reducing perinatal mortality from meta-analyses that do not employ methods that appropriately incorporate contextual variation and

adequately consider the quality of included studies. The need to update evidence on MWH effectiveness using well-designed studies from diverse settings that reflect current levels of service use and quality remains.

Abbreviations

CI: Confidence interval; MWH: Maternity waiting homes; RR: Relative risk.

Acknowledgements

We would like to acknowledge the feedback provided by Dr. Manisha Kulkarni, Dr. Gail Webber and an anonymous colleague on earlier versions of the manuscript. We would also like to recognize the constructive feedback from the anonymous reviewer which greatly improved the article.

Authors' contributions

JK conceived of the study, conducted the analysis of the study for illustrative purposes with ZL and drafted the first draft of the manuscript. JK, ZL, KH and KW were involved in interpretation of the results, reviewing and revising the manuscript, and all approved its final version. All authors read and approved the final manuscript.

Funding

The authors did not receive any funding for this work.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

¹ School of Epidemiology & Public Health, University of Ottawa, 600 Peter Morand Crescent, Ottawa, ON K1G 5Z3, Canada. ² Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, MA 02115, USA. ³ Judith Lumley Centre and Institute for Human Security & Social Change, La Trobe University, Plenty Road, Bundoora, Melbourne 3086, Australia. ⁴ Robinson Research Institute, Adelaide Medical School, The University of Adelaide, Helen Mayo North, 30 Frome Street, Adelaide, Australia.

Received: 1 October 2020 Accepted: 25 February 2021

Published online: 09 March 2021

References

- World Health Organization. Maternity waiting homes: a review of experiences. Geneva: World Health Organization; 1996.
- Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa: Ministry of Health Ethiopia; 2015.
- World Health Organization. WHO Recommendations on health promotion interventions for maternal and newborn health. Geneva: World Health Organization; 2015.
- Wild K, Kelly P, Barclay L, Martins N. Agenda setting and evidence in maternal health: connecting research and policy in timor-leste. *Front Public Heal*. 2015;3(September):1–9.
- Lori JR, Perosky JE, Rominski S, Munro-Kramer ML, Cooper F, Kofa A, et al. Maternity waiting homes in Liberia: Results of a countrywide multi-sector scale-up. *PLoS ONE*. 2020;15(6):e0234785.
- Lori JR, Perosky J, Munro-kramer ML, Veliz P, Musonda G, Kaunda J, et al. Maternity waiting homes as part of a comprehensive approach to maternal and newborn care: a cross-sectional survey. *BMC Pregnancy Childbirth*. 2019;19:228.
- Braat F, Vermeiden T, Getnet G, Schiffer R, van den Akker T, Stekelenburg J. Comparison of pregnancy outcomes between maternity waiting home users and non-users at hospitals with and without a maternity waiting home: retrospective cohort study. *Int Health*. 2018;10:47–53.
- Kelly J, Kohls E, Poovan P, Schiffer R, Redito A, Winter H, et al. The role of a maternity waiting area (MWA) in reducing maternal mortality and stillbirths in high-risk women in rural Ethiopia. *BJOG*. 2010;117(11):1377–83.
- van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012. <https://doi.org/10.1002/14651858.CD006759.pub3>.
- Buser JM, Lori JR. Newborn outcomes and maternity waiting homes in low and middle-income countries: a scoping review. *Matern Child Health J*. 2016. <https://doi.org/10.1007/s10995-016-2162-2>.
- Bekele BB, Dadi TL, Tesfaye T. The significant association between maternity waiting homes utilization and perinatal mortality in Africa: systematic review and meta-analysis. *BMC Res Notes*. 2019;12:13.
- Bonawitz R, Mcglasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia : a mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS ONE*. 2019;14(11):e0225523.
- Getachew B, Liabsuetrakul T, Gebrehiwot Y. Association of maternity waiting home utilization with women's perceived geographic barriers and delivery complications in Ethiopia. *Int J Heal Plan Manag*. 2019. <https://doi.org/10.1002/hpm.2940>.
- Kaiser JL, Fong RM, Ngoma T, Mcglasson KL, Biemba G, Hamer DH, et al. The effects of maternity waiting homes on the health workforce and maternal health service delivery in rural Zambia: a qualitative analysis. *Hum Resour Health*. 2019;17:93.
- Perosky JE, Lockhart MLN, Musonda GK, Naggayi A, Lori JR. Maternity waiting homes as an intervention to increase facility delivery in rural Zambia. *Int J Gynaecol Obstet*. 2019. <https://doi.org/10.1002/ijgo.12864>.
- Pujihartati SH, Wijaya M, Demartoto A. The importance of socializing maternity waiting home in the attempt of reducing maternal mortality rate in wonogiri regency. *Adv Soc Sci Educ Humanit Res*. 2020;389:116–20.
- Tiruneh GT, Getu YN, Abdukie MA, Eba GG, Keyes E, Bailey PE. Distribution of maternity waiting homes and their correlation with perinatal mortality and direct obstetric complication rates in Ethiopia. *BMC Pregnancy Childbirth*. 2019;19:214.
- Coley KM, Perosky JE, Nyanplu A, Kofa A, Anankware JP, Moyer CA, et al. Acceptability and feasibility of insect consumption among pregnant women in Liberia. *Matern Child Nutr*. 2020. <https://doi.org/10.1111/mcn.12990>.
- Idris IO, Araoye D, Chijioke OD, Gavkalova N. A Policy Discussion on maternity waiting home in Zambia to achieve its vision 2030 on maternal and perinatal mortality. *J Fam Med Heal Care*. 2020;6(1):1–7.
- Chandramohan D, Cutts F, Millard P. The effect of stay in a maternity waiting homes on perinatal mortality. *J Trop Med Hyg*. 1995;98:261–7.
- Fogliati P, Straneo M, Mangi S, Azzimonti G, Kisika F, Putoto G. A new use for an old tool: maternity waiting homes to improve equity in rural child-birth care. Results from a cross-sectional hospital and community survey in Tanzania. *Health Policy Plan*. 2017;32:1354–60.
- Lori JR, Munro ML, Rominski S, Williams G, Dahn BT, Boyd CJ, et al. Maternity waiting homes and traditional midwives in rural Liberia. *Int J Gynecol Obstet*. 2013;123(2):114–8.
- Meshesha B, Dejene G, Hailemariam T. The role of maternity waiting area in improving obstetric outcomes: a comparative cross-sectional study, Jinka Zonal Hospital, Southern regional state. *J Womens Heal Care*. 2017;6:6.
- Poovan P, Kifle F, Kwast BE. A maternity waiting home reduces obstetric catastrophes. *World Health Forum*. 1990;11(4):440–5.
- Singh K, Speizer I, Kim ET, Lemani C, Phoya A. Reaching vulnerable women through maternity waiting homes in Malawi. *Int J Gynaecol Obstet*. 2017;136:91–7.
- Spaans W, van Roosmalen J, van Wiechen CMA. A maternity waiting home experience in Zimbabwe. *Int J Gynecol Obstet*. 1998;61(2):179–80.

27. van Lonkhuijzen L, Stegeman M, Nyirongo R, van Roosmalen J. Use of maternity waiting home in rural Zambia. *Afr J Reprod Health*. 2003;7(1):32–6.
28. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis. 1st ed. Chichester: John Wiley & Sons Ltd; 2009. p. 412.
29. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. *Res Synth Method*. 2010. <https://doi.org/10.1002/jrsm.12>.
30. Higgins JPT, Chandler J, Cumpston M, Li T, Page M, Welch V. *Cochrane handbook for systematic reviews of interventions* (version 6.0). Hoboken: Wiley; 2019.
31. Pigott T. *Advances in Meta-Analysis*. New York: Springer, US; 2012.
32. Heterogeneity BM. Common mistakes in meta-analysis and how to avoid them. 1st ed. Englewood: Biostat Incorporated; 2019. p. 75–137.
33. Higgins JPT. Commentary: Heterogeneity in meta-analysis should be expected and appropriately quantified. *Int J Epidemiol*. 2008;37:1158–60.
34. Metelli S, Chaimani A. Challenges in meta-analyses with observational studies. *Evid Based Ment Heal*. 2020;23:83–7.
35. Tanner-smith EE, Grant S. Meta-analysis of complex interventions. *Annu Rev Psychol*. 2018;39:135–51.
36. Penn-Kekana L, Pereira S, Hussein J, Bontogon H, Chersich M, Munjanja S, et al. Understanding the implementation of maternity waiting homes in low- and middle-income countries: a qualitative thematic synthesis. *BMC Pregnancy Childbirth*. 2017;17:269.
37. Higgins JPT, Thompson SG, Spiegelhalter DJ. A re-evaluation of random-effects meta-analysis. *J R Stat Soc*. 2009;172(Part 1):137–59.
38. Higgins JPT, López-López JA, Becker BJ, Davies SR, Dawson S, Grimshaw JM, et al. Synthesising quantitative evidence in systematic reviews of complex health interventions. *BMJ Glob Heal*. 2019;4:e000858.
39. Mueller M, Addario MD, Egger M, Cevallos M, Dekkers O, Mugglin C, et al. Methods to systematically review and meta-analyse observational studies: a systematic scoping review of recommendations. *BMC Med Res Methodol*. 2018;18:44.
40. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
41. Millard P, Bailey J, Hanson J. Antenatal village stay and pregnancy outcome in rural Zimbabwe. *Cent Afr J Med*. 1991;37(1):1–4.
42. Tumwine JK, Dungare PS. Maternity waiting shelters and pregnancy outcome: experience from a rural area in Zimbabwe. *Ann Trop Paediatr*. 1996;16(1):55–9.
43. Viswanathan M, Mcpheeters ML, Murad MH, Butler ME, Beth EE, Dyson MP, et al. AHRQ series on complex intervention systematic reviews paper 4: selecting analytic approaches. *J Clin Epidemiol*. 2017;90:28–36.
44. Neogi SB, Sharma J, Negandhi P, Chauhan M, Reddy S, Sethy G. Risk factors for stillbirths: how much can a responsive health system prevent ? *BMC Pregnancy Childbirth*. 2018. <https://doi.org/10.1186/s12884-018-1660-1>.
45. Lawn JE, Blencowe H, Waiswa P, Amouzou A, Mathers C, Hogan D, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *Lancet*. 2016;387:587–603.
46. Downes MJ, Brennan ML, Williams HC, Dean RS. Development of a critical appraisal tool to assess the quality of cross-sectional studies (AXIS). *BMJ Open*. 2016;6:e011458.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions



Chapter 3.

A3.1. Ethical approvals obtained

The following certificates of Ethics Approval obtained from University of Ottawa to conduct thesis research are included:

1. Certificate dated 15th January 2018 (File Number: H10-15-25B) including me as a student researcher on the approved Safe Motherhood Project to enable use of the survey data.
2. Certificate dated 8th March 2018 (File Number: H02-18-02) approving my doctoral research project.

A letter from the Jimma University Office of Research and Ethics Integrity dated 9th January 2018 confirming and approving of my role on the Safe Motherhood project as student researcher with a doctoral research project nested within the larger approved study.

The approvals are included between thesis pages 298-302.



Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Ethics Approval Notice

Health Sciences and Science REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Ronald	Labonté	Medicine / Medicine	Principal Investigator
Lakew	Abebe	Health Sciences / Others	Co-Principal Investigator
Manisha	Kulkarni	Medicine / Medicine	Co-Principal Investigator
Sudhakar	Morankar	Others / Others	Co-investigator
Jaameeta	Kurji	Medicine / Medicine	Student Researcher

File Number: H10-15-25B

Type of Project: Professor

Title: An Implementation Study of Interventions to Promote Safe Motherhood in Jimma Zone, Ethiopia

Renewal Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
06/02/2017	06/01/2018	Renewal

Special Conditions / Comments:

N/A



Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

This is to confirm that the University of Ottawa Research Ethics Board identified above, which operates in accordance with the Tri-Council Policy Statement (2010) and other applicable laws and regulations in Ontario, has examined and approved the ethics application for the above named research project. Ethics approval is valid for the period indicated above and subject to the conditions listed in the section entitled "Special Conditions / Comments".

During the course of the project, the protocol may not be modified without prior written approval from the REB except when necessary to remove participants from immediate endangerment or when the modification(s) pertain to only administrative or logistical components of the project (e.g., change of telephone number). Investigators must also promptly alert the REB of any changes which increase the risk to participant(s), any changes which considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project and safety of the participant(s). Modifications to the project, including consent and recruitment documentation, should be submitted to the Ethics Office for approval using the "Modification to research project" form available at: <https://research.uottawa.ca/ethics/forms>.

Please submit an annual report to the Ethics Office four weeks before the above-referenced expiry date to request a renewal of this ethics approval. To close the file, a final report must be submitted. These documents can be found at: <https://research.uottawa.ca/ethics/forms>.

If you have any questions, please do not hesitate to contact the Ethics Office at extension 5387 or by e-mail at: ethics@uOttawa.ca.

Signature:

Mélanie Rioux
Ethics Coordinator
For Catherine Paquet, Director of the Office of Research Ethics and Integrity



Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Certificate of Ethics Approval

Health Sciences and Science REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Manisha	Kulkarni	Medicine / Medicine	Supervisor
Ronald	Labonté	Medicine / Medicine	Co-Supervisor
Jaameeta	Kurji	Medicine / Medicine	Student Researcher

File Number: H02-18-02

Type of Project: PhD Thesis

Title: Assessing the Determinants of Maternal Healthcare Service Utilization and the Effectiveness of Intervention to Improve Facility-Based Deliveries in Jimma Zone, Ethiopia

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
03/08/2018	03/07/2019	Initial

Special Conditions / Comments:

N/A



Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

This is to confirm that the University of Ottawa Research Ethics Board identified above, which operates in accordance with the Tri-Council Policy Statement and other applicable laws and regulations in Ontario, has examined and approved the application for ethical approval for the above named research project as of the Ethics Approval Date indicated for the period above and subject to the conditions listed the section above entitled "Special Conditions / Comments".

During the course of the study the protocol may not be modified without prior written approval from the REB except when necessary to remove participants from immediate endangerment or when the modification(s) pertain to only administrative or logistical components of the study (e.g. change of telephone number). Investigators must also promptly alert the REB of any changes which increase the risk to participant(s), any changes which considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project and safety of the participant(s). Modifications to the project, information/consent documentation, and/or recruitment documentation, should be submitted to this office for approval using the "Modification to research project" form available at: <http://research.uottawa.ca/ethics/submissions-and-reviews>.

Please submit an annual status report to the Protocol Officer 4 weeks before the above-referenced expiry date to either close the file or request a renewal of ethics approval. This document can be found at: <http://research.uottawa.ca/ethics/submissions-and-reviews>.

If you have any questions, please do not hesitate to contact the Ethics Office at extension 5387 or by e-mail at: ethics@uOttawa.ca.



Germain Zongo
Protocol Officer for Ethics in Research
For Daniel Lagarec, Chair of the Sciences and Health Sciences REB



JIMMA UNIVERSITY

ጅማ ዩኒቨርሲቲ

ቁጥር

Ref.No

HB/106/2018

ቀን

Date

09 Jan 2018

Office of Research Ethics and Integrity
University of Ottawa
550 Cumberland (Pavillion Tabaret Hall), Room 156
Ottawa, ON
K1N 6N5
Canada

RE: Permission for use of data

To Whom It May Concern:

It is with pleasure that I grant permission for Ms. Jaameeta Kurji to access data from the research project "An Implementation Study of Interventions to Promote Safe Motherhood in Jimma Zone, Ethiopia (H-10-15-25B) for her Doctoral thesis project in Epidemiology at the University of Ottawa.

Her project entitled "Assessing the determinants of maternal healthcare service utilization and effectiveness of interventions to improve facility-based deliveries in Jimma Zone, Ethiopia" with the following research objectives.

Objective 1: To identify the significant predictors, and gain insight into the drivers of MWA use in the three study districts in Jimma Zone, Ethiopia;

Objective 2: To characterize spatial variation in relationships detected between important health facility access predictors and maternal healthcare service utilization in the three study districts in Jimma Zone, Ethiopia;

Objective 3: To assess the effectiveness of upgraded MWAs and leader training in improving the coverage of health facility-based deliveries in the three study districts in Jimma Zone, Ethiopia.

Her research objective is aligned with the overall project aim to improve maternal health in Ethiopia and permission is granted to Ms. Jaameeta Kurji to work on it.

Sincerely,

[Redacted Signature]
Director of
Behavior



Tel. +251-47 11 114 57
PBX: +251471111458-60

Fax: +2514711114 50
+251471112040

P.O.Box. 378
JIMMA, ETHIOPIA

E-mail: ero@ju.edu.et
website: <http://www.ju.edu.et>

A3.2. Trial Protocol paper

A re-print of the published trial protocol is included here under the Creative Commons Attribution 4.0 International License which allows unrestricted use, distribution and reproduction in any medium. The link to the Creative Commons License is: <http://creativecommons.org/licenses/by/4.0/>

The details of the trial methodology employed are described in this article on which I was a primary co-author with my supervisor Dr. Manisha Kulkarni.

Article citation:

Kurji, J., Kulkarni, M.A., Gebretsadik, L.A. et al. Effectiveness of upgraded maternity waiting homes and local leader training in improving institutional births among women in the Jimma zone, Ethiopia: study protocol for a cluster-randomized controlled trial. *Trials* 20, 671 (2019). <https://doi.org/10.1186/s13063-019-3755-z>

The re-print is included between thesis pages 304-314.

STUDY PROTOCOL

Open Access

Effectiveness of upgraded maternity waiting homes and local leader training in improving institutional births among women in the Jimma zone, Ethiopia: study protocol for a cluster-randomized controlled trial



Jaameeta Kurji^{1*}, Manisha A. Kulkarni^{1†}, Lakew Abebe Gebretsadik², Muluemebet Abera Wordofa³, Sudhakar Morankar², Kunuz Haji Bedru⁴, Gebeyehu Bulcha⁴, Kednapa Thavorn⁵, Ronald Labonte¹ and Monica Taljaard⁶

Abstract

Background: Ethiopia is one of the ten countries in the world that together account for almost 60% of all maternal deaths. Recent reductions in maternal mortality have been seen, yet just 26% of women who gave birth in Ethiopia in 2016 reported doing so at a health facility. Maternity waiting homes (MWHs) have been introduced to overcome geographical and financial barriers to institutional births but there is no conclusive evidence as to their effectiveness. We aim to evaluate the effects of upgraded MWHs and local leader training in increasing institutional births in the Jimma zone of Ethiopia.

Methods: A parallel, three-arm, stratified, cluster-randomized controlled trial design is being employed to evaluate intervention effects on institutional births, which is the primary outcome. Trial arms are: (1) upgraded MWH + religious/community leader training; (2) leader training alone; and (3) standard care. Twenty-four primary health care unit catchment areas (clusters) have been randomized and 3840 women of reproductive age who had a pregnancy outcome (livebirth, stillbirth or abortion) are being randomly recruited for each survey round. Outcome assessments will be made using repeat cross-sectional surveys at baseline and 24 months postintervention. An intention to treat approach will be used and the primary outcome analysed using generalized linear mixed models with a random effect for cluster and time. A cost-effectiveness analysis will also be conducted from a societal perspective.

Discussion: This is one of the first trials to evaluate the effectiveness of upgraded MWHs and will provide much needed evidence to policy makers about aspects of functionality and the community engagement required as they scale-up this programme in Ethiopia.

Trial registration: ClinicalTrials.gov, NCT03299491. Retrospectively registered on 3 October 2017.

Keywords: Ethiopia, Maternal health care, Maternity waiting home, Institutional birth, Cluster-randomized controlled trial, Complex interventions, Community engagement, Three-Delays model, RE-AIM framework

* Correspondence

Jaameeta Kurji and Manisha A. Kulkarni are co-primary authors.

[†]School of Epidemiology and Public Health, University of Ottawa, 600 Peter Morand Crescent, Ottawa, ON K1G 5Z3, Canada

Full list of author information is available at the end of the article



© The Author(s). 2019 **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated.

Background

The recently established Sustainable Development Goals reaffirm a global commitment to reducing maternal mortality [1]. Significant progress was made in reducing maternal mortality worldwide during the Millennium Development Goal period from 1990 to 2015; however, levels remain unacceptably high and large regional disparities exist. Globally, maternal mortality in 2015 was 216 per 100,000 livebirths, while in sub-Saharan Africa the rate was more than double this (546 per 100,000 livebirths). Ethiopia is one of the ten countries in the world that together account for almost 60% of all maternal deaths [2].

The majority of maternal deaths are preventable if women have timely access to good-quality maternal health-care services. Access to skilled obstetric care during and soon after birth is critical for the survival of women. However, in Ethiopia, only 26% of women who gave birth in 2016 reported doing so at a health facility [3]. In fact, over 40% of births were overseen by traditional birth attendants and in 15% women were entirely on their own [3]. Obstetric services are provided at the health centre and hospital level but are not available at community-based health posts.

Several barriers have been identified in rural sub-Saharan African that can impact a woman's ability to access skilled obstetric care. These include barriers in the decision to seek care, barriers in reaching care, and barriers in receiving quality care once they arrive at a health facility, commonly referred to as the "three delays" [4]. Community-based interventions are often implemented to address the first two barriers [5–7], while the third barrier requires health system improvement on several levels [8].

Geographical and financial barriers are frequently cited as barriers to reaching skilled obstetric care during and after birth [9]. Women regularly have to travel large distances across difficult terrain, often made impassable during the rainy seasons, to get to health facilities [10]. Transportation options are frequently limited and may be expensive, leading to a limiting effect on the utilization of obstetric care [11]. Community-based surveys in Ethiopia report that women who live closer to health facilities are more likely to give birth there; for instance, women who are within a 1-h walking distance have 3.3 times higher odds of delivering at a health facility [12].

To address physical accessibility issues, particularly in rural areas where health facilities equipped with emergency obstetric services are sparsely distributed, maternity waiting homes (MWHs) have been constructed near or within health facilities. Women approaching their delivery date who will have difficulty in reaching a health facility on time are temporarily accommodated in these "homes away from home". Women who are at a high risk for complications during delivery, such as very young mothers, women expecting twins, and those

diagnosed with conditions such as high blood pressure, are also often referred to MWHs [13].

In Ethiopia, the Federal Ministry of Health has developed explicit guidelines pertaining to MWHs that outline referral criteria, minimum standards for accommodation and services to be provided, strategies to mobilize community contributions, and roles of various levels of government in managing MWHs. The challenge, however, lies with implementation and providing an acceptable level of service quality. A national facility assessment in 2012 on all MWHs listed in Federal Ministry of Health records found that the majority of MWHs did not provide food and did not have attendants to clean and maintain the MWHs [14]. Lack of space to accommodate relatives who were relied upon for food supplies and the absence of staff at night and during weekends were among the complaints made. The quality of MWH facilities has also been shown to affect institutional delivery rates in other African countries [15]. Women also expect health workers to check on them while they are at the MWHs and to assist with transfer to delivery rooms when they go into labour. With the effort and expense it takes to come to the MWHs, an absence of antenatal care support at an MWH could make staying at home a preferable option [16].

Community and religious leaders have been reported to be invaluable in mobilizing communities in order to improve access to health services in Ethiopia [17]. Additionally, given the prominent role of community contextual factors such as social norms around institutional births, community beliefs and expectations, and autonomy of decision-making by women, engaging local leaders in efforts to improve the access to care for women is crucial [9, 18].

This cluster-randomized trial is designed to evaluate the effects of upgraded MWHs and local leader training combined, or local leader training alone, versus usual care on the number of institutional births. We hypothesize that both interventions will increase the proportion of women who have institutional births, with the combined intervention expected to result in a greater increase. As secondary objectives, we will evaluate the effect of the interventions on antenatal care and postnatal care utilization and compare the costs and health outcomes associated with each intervention from the societal perspective.

Methods

Setting

The trial is being conducted in three rural districts (Gomma, Seka Chekorsa and Kersa) in the Jimma zone located in southwestern Ethiopia. These districts were selected from among the 18 districts located in the Jimma zone because: 1) they had the largest available populations; 2) MWHs were present at health centres; and 3) they did not have any active maternal and child health interventions at the time.

Intervention components

Two interventions are being evaluated in the trial: upgraded MWHs and local leader training combined, and local leader training alone.

Upgraded MWHs

Existing MWHs will be provided with supplies to create a home-like environment suitable for pregnant women to reside in prior to delivery. The supplies provided were selected based on a review of existing literature, a rapid-needs assessment conducted at baseline, and input from the Jimma Zone Health Office (JZHO). Eleven indicators are used to specify the minimum required services at MWHs and these include room(s) with the capacity for at least 10 women, bedding, a kitchen with a chimney, a food supply, materials for the coffee ceremony (an important cultural routine for families), a clean water supply, a power source, toilet facilities, a bathing area, an attendant for the MWH, and follow-up by a skilled birth attendant. Items supplied are listed in Table 1.

A register was also codesigned with the JZHO and introduced to facilitate tracking of MWH users and services provided as outlined in the national MWH policy guideline. The register is managed by antenatal care nurses who refer women to MWHs and are responsible for monitoring pregnant users during their stay prior to delivery. Funds are also provided to employ an attendant to clean the MWH, prepare meals and assist users during their stay at the MWH.

Local leader training

Community-based health extension workers (HEWs), religious leaders, and community leaders (specifically the Women's Development Army) are targeted for the training workshops. The training aims to facilitate identification of barriers to accessing maternal health-care services and strategies to overcome these. The workshops use participatory learning methods that build on individual experiences. HEWs, who are employed by the Ethiopian health system, are invited to attend 3-day workshops while

religious and local leaders attend 1-day workshops. Content for the workshops were developed by the research team based on barriers to care identified in the Three Delay Model and through formative, qualitative research carried out in 2016 [19]. Leaders are expected to integrate what they learn into their routine engagement with the communities to promote safe motherhood practices including accessing maternal health-care services and use of MWHs.

Standard care (control group)

MWHs were officially introduced around 2013 and have gradually been scaled up across the country. These are modelled as a community–government partnership with a significant reliance on community contributions for their sustainability. Communities make both cash and in-kind contributions in the form of coffee and/or food. There is large variation in the availability of supplies and quality of services provided amongst MWHs. This is partly due to a fluctuation in resources available during the year among families and partly due to a weak management system. No records are maintained of MWH users and, in practice, there is very little monitoring of women who stay at these facilities. JZHO data suggest that, at baseline, the majority of MWHs in the study area were either very poorly or poorly functional based on the 11 service indicators. The national guidelines specify that women who live at a distance from health facilities or cannot be reached by ambulance or are 38 weeks pregnant or more and at risk of experiencing obstetric complications should be referred for MWH stay [20]. However, women are typically referred to MWHs when they present with false labour or arrive at the very early stages of labour. A smaller proportion of women are referred to MWHs by antenatal care nurses if they live very far away from a health centre and are expected to deliver in a few weeks. Referral practices vary among health centres and staff.

Health promotion activities are mainly conducted by HEWs who are sometimes assisted by members of the Women's Development Army. Although some religious leaders may encourage their community members to deliver at health facilities, this is not a widespread or systematic practice in the study districts.

Trial design

This study is a parallel, three-arm, stratified, cluster-randomized controlled, superiority trial with 24 clusters. The trial arms are as follows: 1) upgraded MWH + leader training; 2) leader training alone; and 3) standard care. Primary health-care unit (PHCU) catchment areas were designated as clusters for the trial. PHCUs are composed of a health centre and satellite health posts; health posts operate in the community, covering a

Table 1 Supplies provided to upgrade maternity waiting homes (MWHs) as part of the MWH intervention component

Bedding	Utensils	Personal hygiene	Other
Mattresses	Coffee grinder	Bath towels	Solar lamps
Bed sheets	Glasses	Buckets	Water tank (1000 l)
Pillows	Plates	Slippers	Cooking stove
Blankets	Water jug	Soap	Broom
	Coffee cups	Washing powder	Plastic floor sheets
	Coffee pot	Sanitary pads	Mop
	Local bread pan		Bleach
	Pots		Drinking water purifier

population of 3000–5000 and are each managed by two to three HEWs. MWHs are located within health centres as standalone structures or in the form of a room assigned to function as an MWH. Outcome assessments will be made using repeat cross-sectional surveys at baseline (prior to intervention roll-out) and at 24 months postintervention (i.e. the endline). A schematic for the trial design is displayed in Fig. 1. A cluster-randomized design was selected because the interventions are delivered at the health facility and community level which precludes individual-level randomization.

Cluster and individual selection

PHCUs were eligible for trial participation if health centres had a standalone MWH or a room designated for this purpose. All 26 health units in the three districts

were eligible and 24 were randomly selected for the trial using a random number generator in STATA v13.

Women of reproductive age were eligible to participate in the trial if they were living in the villages within the selected PHCU catchment areas and had a pregnancy outcome (livebirth, stillbirth, spontaneous/induced abortion) up to 12 months prior to a survey round; baseline surveys commenced in October 2016 and endline surveys are scheduled to begin in April 2019. Lists of pregnant women registered by HEWs at health posts and Women's Development Army volunteers within villages ('kebeles') function as the sampling frame for selection of eligible women at each survey time point. Names of women, their village of residence and their date of delivery organized by PHCU are included in the sampling frame. Random numbers generated in STATA v13 were assigned to each woman in the list, ranked, and then the

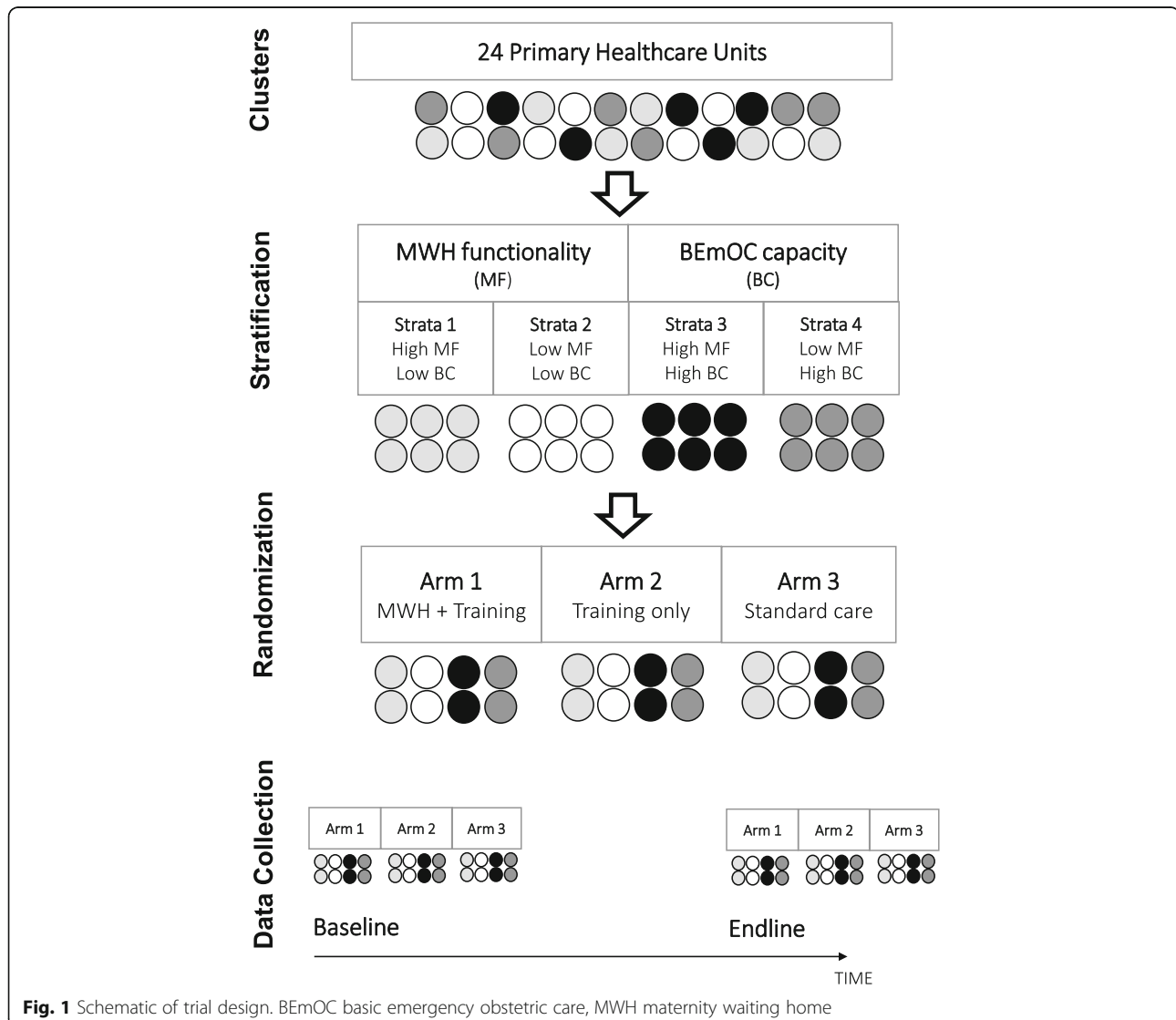


Fig. 1 Schematic of trial design. BEmOC basic emergency obstetric care, MWH maternity waiting home

required number sequentially selected. Since women were not excluded based on prior participation in surveys, it is possible that there is some overlap of participation in baseline and endline surveys, but the probability is expected to be low.

Intervention assignment and masking

Stratification was employed to ensure a balanced distribution of poorly functioning MWHs and low basic emergency obstetric care (BEmOC) capacity health centres between the trial arms. JZHO data on MWH functionality assessed using the 11 indicators were used to classify clusters as high functioning (≥ 5 of 11 MWH indicators present) or low functioning (< 5 of 11 MWH indicators present). Clusters were also grouped based on their capacity to provide BEmOC; high-capacity clusters were those that had at least 5 of the 7 signal functions present while low-capacity clusters had less than 5 signal functions present according to 2016 JZHO data. Signal functions are essential obstetric interventions, such as provision of parenteral anticonvulsants, necessary to prevent maternal deaths; they are used to assess the level of obstetric care provided at health facilities [21].

Clusters were stratified into four groups based on these strata (low MWH + low BEmOC; low MWH + high BEmOC; high MWH + low BEmOC; high MWH + high BEmOC). Within each stratum, a random number generator in STATA was used to generate the allocation schedule. The allocation sequence was generated by MAK who was not involved in implementing the trial and it was shared in a password-protected document with the principal investigator in Ethiopia (LAG) who was also not involved in recruitment and enrolment of clusters or individuals. Random allocation of clusters to trial arms took place once all clusters had been recruited for the study.

Interviewers collecting outcome data are blind to intervention assignment. Due to the nature of the intervention it is not possible to blind women or health-care providers at PHCUs to their intervention status. However, all women and health-care providers are blind to the study hypotheses. The consent for data collection includes a general description of the overall aims of the study (namely to understand the experiences of women when they are pregnant, giving birth and after delivery and to look for ways to make this safer for women and their babies), but women are not aware of their cluster's allocation to the intervention or control arms.

Participant timeline

Clusters were enrolled in March 2016 and randomized to trial arms in September 2016. Baseline recruitment and interviewing of women within study clusters began in October 2016 and was completed by January 2017.

Distribution of materials to the MWHs and training of leaders and HEWs commenced in May 2017; upgraded MWHs were operational in June 2017. The endline assessments are scheduled to start in April 2019. An outline of the trial timeline is illustrated in Fig. 2.

In terms of participation in outcome assessments, women who are randomly selected for interviews at baseline and endline typically spend 25 min on average giving consent and about an hour for interviews.

Sample size

Methods outlined by Hooper and Bourke [22] for parallel-arm, cluster-randomized trials with repeated cross-sections were used to calculate the sample size (see Additional file 1). Briefly, the methodology requires calculation of two design effects, with the product of the two used to inflate the sample size under individual randomization to account for within-period intracluster correlation coefficient (ICC) and the between-period ICC. The within-period ICC is the correlation between any two women in the same cluster and the same period, while the between-period ICC is the correlation between any two women in the same cluster but different periods.

The first design effect (d_c) due to cluster randomization was calculated using a within-period ICC of 0.1 obtained from a review of community-based, cluster-randomized controlled trials in low-resource settings focusing on maternal health-care service outcomes [23]. The design effect was calculated as:

$$d_c = 1 + (m - 1)\rho$$

where m is the cluster-period size (i.e. the number of women surveyed per PHCU in each round) and ρ is the within-period ICC.

The second design effect (d_r) due to repeated assessments (baseline and endline) was calculated using both the within-period ICC and a cluster autocorrelation coefficient (π) of 0.8 to allow for a 20% decay of the correlation from within to between different periods [22]. We had no prior information to inform the cluster autocorrelation coefficient, but a 20% decay was considered reasonable. The second design effect was calculated as:

$$d_r = (1 - r^2)$$

where $r = (m\rho\pi)/d_c$.

The sample size assuming individual randomization was then multiplied by both design effects to arrive at a required sample size of eight PHCUs per arm with an average of 160 women per PHCU per round of survey, for a total sample size of 3840 for each survey (total women recruited = 7680). This sample size achieves 80% power to detect an absolute difference in the proportions of institutional births of 0.17 assuming a control arm

TRIAL MILESTONES	2016				2017				2018				2019		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
ENROLMENT															
Cluster selection	X														
Cluster randomization			X												
Woman recruitment				X	X									X	X
INTERVENTION															
MWH supply distribution						X									
Upgraded MWHs operational						X	X	X	X	X	X	X	X	X	X
Leader workshops						X				X					
ASSESSMENTS															
Baseline survey				X	X										
Endline survey														X	X

Q1-Jan, Feb, Mar

Q2-Apr, May, Jun

Q3-Jul, Aug, Sep

Q4-Oct, Nov, Dec

Fig. 2 Tentative trial timeline. MWH maternity waiting home

proportion of 0.4 and using a two-sided alpha of 0.025 to account for two pairwise comparisons. The control arm proportion was obtained from JZHO data. An absolute difference of 0.17 is the smallest difference that can be detected, i.e. the difference between the weakest intervention (hypothesized to be the leader training intervention) arm versus control.

Outcomes

The primary outcome is self-reported institutional birth defined as delivery of the last child at a health facility where obstetric care is provided (i.e. health centre or hospital) as reported by an enrolled woman. Births at home, en route to a facility or at a health post will not be considered an institutional birth.

Two other maternal health-care service outcomes will be assessed: 1) antenatal care and 2) postnatal care. Self-reported antenatal care received for last child delivered as well as the total number of antenatal care visits made will be assessed. Self-reported postnatal care received for the last child delivered within 48 h and 6 weeks will be assessed as secondary outcomes.

Data collection and management

Data on outcomes and other variables of interest are collected through household surveys prior to intervention roll-out (baseline) and after 24 months of implementing the intervention (endline). Trained interviewers will conduct face-to-face interviews using structured questionnaires programmed onto tablet computers using Open Data Kit. Questionnaires contain sections on sociodemographics,

reproductive history, maternal health-care service use, danger sign knowledge, attitudes towards maternal health-care services, awareness of/experience with MWHs, social support and health-related quality of life. Interviews are expected to last approximately 1 h and will be conducted in a quiet, private space at the homes of the women. If selected women are absent from their homes, interviewers will visit households up to three different days/times to attempt to interview them before the woman will be replaced with another randomly selected woman. Some demographic information will be collected from those women who refuse to take part in the trial if they agree to provide this data.

Data collected are submitted to a secure cloud server on a weekly basis from tablet computers. They are checked for inconsistencies and errors and these are communicated to field supervisors and brought to the attention of interviewers to avoid repetition and preserve data quality.

Qualitative data will be collected at baseline and at follow-up. Focus group discussions (with religious leaders and local community leaders) and key informant interviews (with HEWs and health facility staff) will be conducted to understand the roles stakeholders play in maternal and child health, what activities they engage in to promote safe motherhood and what their expectations and experiences are with respect to MWHs. As part of process monitoring, routine meetings held at the district and community level will be periodically attended over the course of the 24-month intervention period; data will be collected primarily using participant observation and field notes.

Primary analysis: effectiveness of the intervention components

Baseline characteristics of women will be tabulated by trial arm to provide an overview of the study population and to check for any notable imbalances. Characteristics of interest will include the age of women, the education levels of women, the distance between home and the nearest health centre, and household wealth. Means, standard deviations and ranges will be presented for continuous variables, while frequencies and percentages will be reported for categorical variables.

An intention to treat approach will be employed where random assignments of clusters to the three trial arms will be preserved regardless of adherence to the intervention assignment. The primary outcome will be analysed using a generalized linear mixed model with random effects for PHCU (cluster) and time, and fixed effects for time, time by trial arm interaction, and the stratification variables. The main effects for trial arm will be dropped to constrain differences between the arms at baseline as recommended by Hooper et al. [24]. With only two measurement points, it will not be possible to

determine whether or not time has a more complex relationship with the outcome (quadratic or cubic) and therefore only a first-order term for time will be included. To account for the bias due to a small number of clusters, we will use the Kenward–Roger degrees of freedom approximation [25].

A logit link function will be used, and the outcome assumed to have a binomial distribution. Pairwise comparisons of adjusted least square mean differences will be made together with 97.5% confidence intervals to determine the effect of each intervention arm versus control.

Odds ratios will be calculated by taking the exponential of the relevant combinations of regression coefficients. The ICC and cluster autocorrelation coefficient for institutional births (primary outcome), antenatal care use, and postnatal care use will be calculated in STATA and reported on the proportions scale. Secondary outcomes will be analysed as described for the primary outcome.

Statistical tests and confidence intervals will be two-sided; between-group comparisons will be calculated and presented with 95% confidence intervals with the significance levels set at the 2.5% level.

Secondary analysis: understanding implementation for scale-up

Due to the pragmatic nature of the trial and an interest in supporting scale-up, if found to be effective, the RE-AIM framework is being used to guide secondary analyses focusing on implementation. Briefly, the impact of an intervention is assessed by evaluating reach, efficacy, adoption, implementation, and maintenance [26]. Reach and efficacy measures are captured in our primary and secondary trial outcomes; adoption, implementation and maintenance of the intervention components will be gauged using qualitative data collected from HEWs, health centre staff, and district and zonal health office staff. Uptake of the intervention components, changes in policy implementation and financial support as well as mechanisms used to sustain the interventions that develop during the trial will be examined. Finally, the short- and long-term cost-effectiveness of the intervention components will be determined using a decision analytic modelling approach. The short-term cost-effectiveness analysis will be based on trial data as well as data specific to the Jimma zone and Ethiopia. This short-term study will provide an incremental cost per intermediate outcomes, including the number of women who have institutional births. A Markov model will be developed and used to simulate the natural history of pregnancy, pregnancy-related complications, and the long-term cost-effectiveness of maternal and neonatal interventions of interest over the lifetime period of women. The outcomes of the long-term model will be expressed as an incremental cost per an additional life year saved. We will conduct extensive sensitivity

analyses, including both deterministic and probabilistic sensitivity analysis with Monte-Carlo simulations, to assess the robustness of our model to parameter uncertainty. Where possible, we will utilize the regression analyses on baseline sociodemographic characteristics associated with cost and outcome and stratify the simulated cohort to reflect these sources of variability in cost-effectiveness outcomes.

Ethics and dissemination

Research ethics approval

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File no. H10–15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref. no. RPGE/449/2016). Informed consent will be obtained from all study participants.

Protocol amendments

The trial was initially designed with three rounds of survey, but due to budget constraints the protocol was changed to include only two surveys (baseline and end-line). This was done after the baseline survey but prior to analysis. This resulted in the minimum absolute detectable difference increasing from 15% to 17% to maintain other sample size parameters (80% power, ICC = 0.1 and 24 clusters with 160 women each). An economic analysis component was also included (protocol version 3.0, January 2016) and consent forms simplified as per ethics board feedback (protocol version 2.0, October 2015).

Informed consent

In this setting, there is a close relationship between the community and administrative structures at various levels. The JZHO primarily formulates health policies and works closely with the district health office which in turn supervises implementation and service delivery at the PHCU level. The community is actively engaged through community-based HEWs and the Women's Development Army which regularly interfaces with the PHCU staff. Through this cascade, information about the trial was informally shared by Jimma University partners (who independently have a respected, long-standing relationship with the community through their research and development work) and approval for cluster participation secured prior to commencing the study. Concerns about which clusters would be allocated to intervention at the district level were addressed by explaining the importance of preserving random allocation and by assurances that interventions found to be effective would be scaled-up.

Verbal informed consent for data collection is obtained from eligible women willing to participate in interviews prior to either round of household surveys.

Trained interviewers read out the contents of the consent forms outlining the survey objectives, institutions and investigators involved and describing what is expected of women as well as associated risks and benefits. This is done in a local language of choice (Amharic or Afaan Oromo). Women are also explained their rights as participants and their questions answered prior to enrolment. Since clusters are randomized before the surveys, women who consent to take part in surveys will be providing consent after randomization has already taken place. It is not possible to obtain individual consent for study interventions as the interventions are delivered at the level of the entire community.

Confidentiality

The names of the women, the village of residence and point location of dwelling are collected on encrypted questionnaires and stored separately from the rest of the collected data. Names are collected to detect and correct errors in study identification number assignment. Point locations are collected for planned spatial analyses distinct from intervention effectiveness analysis, the latter being the primary focus of this trial. Only the principal investigators in Jimma, Ethiopia, and Ottawa, Canada, have access to this personal identifier information. Data shared with the research team for analysis purposes will be de-identified first by removing the names of the women.

Dissemination plan

A National Advisory Committee consisting of individuals from institutions such as the Federal Ministry of Health, Ethiopian Public Health Institute and the Ministry of Science and Technology is being engaged to enhance policymaker participation and to promote future uptake of effective interventions in a sustainable manner. Annual meetings are held to brief the committee on progress and a final dissemination meeting will be held towards the last few months of the trial. Scientific papers highlighting various study results will also be published in open-access journals.

Discussion

Our study will be among the first of the few trials to assess the effectiveness of MWHs in improving institutional births [27]. There have been several observational studies conducted to evaluate various aspects of MWH effectiveness. Lower maternal mortality and stillbirths among MWH users was reported in a retrospective cohort study in Ethiopia [28]; a hospital-based cohort in Zimbabwe described a higher relative risk of perinatal death among women who delivered at home compared to those who were admitted to a health facility through MWHs [29]; a matched-cohort study in Liberia found an increase in the proportion of skilled deliveries in

facilities with MWHs compared to controls [30]. However, these designs had inherent biases that arose mainly because assignment to exposure was driven by specific factors that may contribute to observed outcomes making causal inference difficult; group comparability was also uncertain. These studies suggest that MWHs have the potential to improve both the coverage of institutional births as well as maternal health outcomes. However, there is a need to generate more reliable evidence using stronger designs such as randomized controlled trials [27].

In terms of design, the risk of contamination has been minimized by randomizing at the PHCU level where both intervention components are mainly delivered. Randomizing at the cluster level, however, can introduce selection bias when recruiters have knowledge of cluster allocation [31]. To minimize this risk, we are using HEW community lists of pregnant women to randomly select individuals within recruited clusters for surveys. Significant time and resources have been invested to ensure these lists are up to date and complete. Despite the logistical challenges of deploying interviewer teams to scattered locations resulting from random selection of women, selections were maintained to preserve trial integrity.

To ensure balance between trial arms and group comparability, clusters were stratified by both MWH functionality and the BEmOC capacity of health centres. BEmOC capacity was used as a proxy for quality of care, which has been reported to affect the primary outcome of institutional births [32–34]. Tablets on which survey data were collected were programmed with required questions to minimize missing outcome data. Interviewers are not able to proceed with the survey if they do not enter responses. Missing data and cluster withdrawal are often of concern in cluster-randomized trials [35]; however, we do not expect cluster withdrawal because policy makers and programme implementers who function as both important stakeholders and community gatekeepers are partnering in the trial. It is possible that women may switch clusters by seeking services outside of their catchment area; however, this is a pragmatic trial aiming to measure effectiveness to inform practice and therefore needs to be able to accommodate such eventualities. We anticipate some nonresponse (due to individuals who decline to participate in the survey) although this is anticipated to occur at random and nondifferentially across the arms. Nevertheless, we will assess the extent of selection bias that may be present by comparing the demographic profile of respondents and nonrespondents.

By combining upgraded MWHs and leader training intervention components, our trial has limited ability to detect the effect of upgraded MWHs alone on increases in institutional births. However, given the

influential effects of the community and context on the willingness and ability of women to access maternal health-care services [36–39], a pragmatic approach that integrates an intervention component to create an enabling environment for women is likely more appropriate. Many women require permission from their husbands to stay at MWHs while others need someone to step in to handle domestic responsibilities and take care of children to enable them to stay at an MWH. Absence of support in these areas hinders some women from using MWHs [14, 16, 40, 41] as it does, more generally, in accessing other maternal health-care services. A lack of awareness of the existence of MWHs and their benefits can also contribute to low usage [16]. Negative perceptions associated with MWH use among communities can discourage women from staying at MWHs [42]. Local religious and community leaders can function as change agents who, if engaged, can positively influence beliefs and practices and mobilize support for women [43, 44].

While the overall goal of any efforts to improve the access of women to maternal health-care services is to reduce maternal mortality, our trial does not have the resources to support the sample size that would be required to detect a change in this relatively rare outcome. We therefore selected institutional births as our primary outcome; this focus aligned well with maternal health indicators used by the Ethiopian Federal Ministry of Health and was endorsed as a useful metric to guide policy implementation and appropriate resource allocation. We also relied on self-reporting by women of institutional births, which may be subject to some limitations due to poor recall.

Finally, embedding the intervention components within the health system with an explicit link to the community should help to facilitate scale-up. The results of this trial will provide much needed evidence to policy makers about the effectiveness and cost-effectiveness of functional MWH and local leader training in improving utilization of maternal health-care services with the overarching goal to reduce maternal mortality.

Trial status

Participant recruitment began on 15 October 2016 and baseline data collection was completed in January 2017. Intervention implementation began in June 2017 and is currently on-going. The endline survey is scheduled to begin in April 2019 and is anticipated to be completed by July 2019, at which time recruitment will also be complete. This is protocol version 3.0, dated 12 January 2016.

Supplementary information

Supplementary information accompanies this paper at <https://doi.org/10.1186/s13063-019-3755-z>.

Additional file 1. Sample size calculation.

Abbreviations

BEmOC: Basic emergency obstetric care; HEW: Health extension worker; ICC: Intraclass correlation coefficient; JZHO: Jimma Zone Health Office; MWH: Maternity waiting home; PHCU: Primary health-care unit

Acknowledgments

We are grateful to the communities who have been generous with their time and thoughts and without whom this trial would not be possible. The authors acknowledge Getachew Kiros, Abebe Mamo, Shifera Asfaw, and Yisalemush Asefa who are involved in the implementation of the trial, Nicole Bergen who was involved in designing the leader training intervention component, and Dr. Corinne Packer for project coordination.

Authors' contributions

MAK, RL, LAG and SM conceptualized the study with input from KHB, GB and MAW; MAK led the overall trial design. MT and JK contributed to details of trial design and specified planned trial analysis. KT led all cost-effectiveness analyses. JK created data collection tools and was involved in designing the MWH intervention. JK and MAK wrote the trial protocol. All authors reviewed and approved the protocol.

Funding

This work was carried out with grant numbers 108028–001 (Jimma University) and 108028–002 (University of Ottawa) from the Innovating for Maternal and Child Health in Africa initiative (co-funded by Global Affairs Canada, the Canadian Institutes of Health Research and Canada's International Development Research Centre); it does not necessarily reflect the opinions of these organizations.

Availability of data and materials

Not applicable.

Ethics approval and consent to participate

Ethical approval was obtained from the University of Ottawa Health Sciences and Science Research Ethics Board (File no. H10–15-25B) and the Jimma University College of Health Sciences Institutional Review Board (Ref. no. RPGE/449/2016). Informed consent will be obtained from all study participants.

Consent for publication

Not applicable. No individual data is included in any form in this publication.

Competing interests

The authors declare that they have no competing interests.

Author details

¹School of Epidemiology and Public Health, University of Ottawa, 600 Peter Morand Crescent, Ottawa, ON K1G 5Z3, Canada. ²Department of Health, Behaviour & Society, Jimma University, Jimma Town, Jimma Zone, Ethiopia. ³Department of Population & Family Health, Jimma University, Jimma Town, Jimma Zone, Ethiopia. ⁴Jimma Zone Health Office, Jimma Town, Jimma Zone, Ethiopia. ⁵Ontario Hospital Research Institute, The Ottawa Hospital - General Campus, Ottawa, ON, Canada. ⁶Ontario Hospital Research Institute, Ottawa Hospital, Civic Campus, 1053 Carling Ave, Civic Box 693, Admin Services Building, ASB 2-004, Ottawa, ON K1Y 4E9, Canada.

Received: 21 January 2019 Accepted: 25 September 2019

Published online: 04 December 2019

References

- United Nations. Sustainable development goals. Available from: <https://sustainabledevelopment.un.org/sdgs>. Cited 12 Aug 2019.
- Alkema L, Broaddus E, Chou D, Hogan D, Mathers C, Moller AB, et al. Trends in maternal mortality 1990 to 2015: estimates by WHO, UNICEF, UNFPA,

- World Bank Group and UN Population Division. 2015. Available at: http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf.
- Central Statistical Agency - CSA/Ethiopia and ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa: CSA and ICF. 2017. Available at <http://dhsprogram.com/pubs/pdf/FR328/FR328.pdf>.
- Thaddeus S, Maine D. Too far to walk: maternal mortality in context. *Soc Sci Med*. 1994;38(8):1091–110.
- Bang K, Chae S, Lee I, Yu J, Kim J. Effects of a community outreach program for maternal health and family planning in Tigray, Ethiopia. *Asian Nurs Res (Korean Soc Nurs Sci)*. 2018;12:223–30.
- Jacobs C, Moshabela M, Maswenyeho S, Lambo N, Michelo C. Predictors of antenatal care, skilled birth attendance, and postnatal care utilization among the remote and poorest rural communities of Zambia: a multilevel analysis. *Front Public Health*. 2017;5(Febuary):11.
- Choulagai BP, Onta S, Subedi N, Bhatta DN, Shrestha B, Petzold M, et al. A cluster-randomized evaluation of an intervention to increase skilled birth attendant utilization in mid- and far-western Nepal. *Health Policy Plan*. 2017;32(8):1092–101.
- Knight HE, Self A, Kennedy SH. Why are women dying when they reach hospital on time? A systematic review of the “third delay”. *PLoS One*. 2013;8(5):e63846.
- Kyei-Nimakoh M, Carolan-Olah M, McCann TV. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. *Syst Rev*. 2017;6(1):110.
- Kumbani L, Bjune G, Chirwa E, Malata A, Odland JØ. Why some women fail to give birth at health facilities: a qualitative study of women's perceptions of perinatal care from rural Southern Malawi. *Reprod Health*. 2013;10(1):9.
- Wong KLM, Benova L, Campbell OMR. A look back on how far to walk: systematic review and meta-analysis of physical access to skilled care for childbirth in sub-Saharan Africa. *PLoS One*. 2017;12(9):1–20.
- Hailu D, Berhe H. Determinants of institutional childbirth service utilisation among women of childbearing age in urban and rural areas of Tsegedie district, Ethiopia. *Midwifery*. 2014;30:1109–17.
- World Health Organization. Maternity waiting homes: a review of experiences. Geneva: WHO; 1996.
- Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia—three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
- Henry EG, Semrau K, Hamer DH, Vian T, Nambao M, Mataka K, et al. The influence of quality maternity waiting homes on utilization of facilities for delivery in rural Zambia. *Reprod Health*. 2017;14(1):68.
- Wilson JB, Collison AHK, Richardson D, Kwofie G, Senah KA, Tinkorang EK. The maternity waiting home concept: the Nsawam, Ghana experience. *Int J Gynecol Obstet*. 1997;59(Suppl.2):S165–72.
- Bradley EH, Byam P, Alpern R, Thompson JW, Zerihun A, Abeb Y, et al. A systems approach to improving rural care in Ethiopia. *PLoS One*. 2012;7(4):e35042.
- Sumankuuro J, Crockett J, Wang S. Sociocultural barriers to maternity services delivery: a qualitative meta-synthesis of the literature. *Public Health*. 2018;157:77–85.
- Bergen N, Mamo A, Asfaw S, Abebe L, Kurji J, Kiros G, et al. Perceptions and experiences related to health and health inequality among rural communities in Jimma Zone, Ethiopia: a rapid qualitative assessment. *Int J Equity Health*. 2018;17(1):84.
- Ministry of Health Ethiopia. Guideline for the establishment of standardized maternity waiting homes at health centres/facilities. Addis Ababa: Ministry of Health Ethiopia; 2015.
- World Health Organization, UNFPA, UNICEF, AMDD. Monitoring emergency obstetric care. A handbook. Geneva: WHO; 2009.
- Hooper R, Bourke L. Cluster randomised trials with repeated cross sections: alternatives to parallel group designs. *Br Med J*. 2015;350(h2925):1–5.
- Pagel C, Prost A, Lewycka S, Das S, Colbourn T, Mahapatra R, et al. Intraclass correlation coefficients and coefficients of variation for perinatal outcomes from five cluster-randomised controlled trials in low and middle-income countries: results and methodological implications. *Trials*. 2011;12(1):151.
- Hooper R, Forbes A, Hemming K, Takeda A, Beresford L. Analysis of cluster randomised trials with an assessment of outcome at baseline. *Br Med J*. 2018;360:k1121.
- Kenward MG, Roger JH. Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics*. 1997;53(3):983–97.

26. Glasgow R, Vogt T, Boles S. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health*. 1999; 89(9):1322–7.
27. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane Database Syst Rev*. 2012;10:CD006759.
28. Kelly J, Kohls E, Poovan P, Schiffer R, Redito A, Winter H, et al. The role of a maternity waiting area (MWA) in reducing maternal mortality and stillbirths in high-risk women in rural Ethiopia. *BJOG*. 2010;117(11):1377–83.
29. Chandramohan D, Cutts F, Millard P. The effect of stay in a maternity waiting home on perinatal mortality in rural Zimbabwe. *J Trop Med Hyg*. 1995;98(4):261–7.
30. Lori JR, Williams G, Munro ML, Diallo N, Boyd CJ. It takes a village: a comparative study of maternity waiting homes in rural Liberia. *Lancet Glob Heal*. 2014;18(1):S11–S11. <https://doi.org/10.1007/s10995-013-1232-y>.
31. Brierley G, Brabyn S, Torgerson D, Watson J. Bias in recruitment to cluster randomized trials: a review of recent publications. *J Eval Clin Pract*. 2012; 18(4):878–86.
32. Gabrysch S, Campbell OMR. Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy Childbirth*. 2009;9:34.
33. Bedford J, Gandhi M, Admassu M, Girma A. "A normal delivery takes place at home": a qualitative study of the location of childbirth in rural Ethiopia. *Matern Child Health J*. 2013;17(2):230–9.
34. Shiferaw S, Spigt M, Godefrooij M, Melkamu Y, Tekie M. Why do women prefer home births in Ethiopia? *BMC Pregnancy Childbirth*. 2013;13:5.
35. Giraudeau B, Ravaud P. Preventing bias in cluster randomised trials. *PLoS Med*. 2009;6(5):e1000065.
36. Stephenson R, Baschieri A, Clements S, Hennink M, Madise N. Contextual influences on the use of health facilities for childbirth in Africa. *Am J Public Health*. 2006;96:84–93.
37. Sialubanje C, Massar K, Kirch EM, Van Der Pijl MSGG, Hamer DH, Ruiter RACC. Husbands' experiences and perceptions regarding the use of maternity waiting homes in rural Zambia. *Int J Gynecol Obstet*. 2016;133:108–11.
38. Mekonnen ZA, Lerebo WT, Gebrehiwot TG, Abadura SA. Multilevel analysis of individual and community level factors associated with institutional delivery in Ethiopia. *BMC Res Notes*. 2015;8:376.
39. Kea AZ, Tulloch O, Datiko DG, Theobald S, Kok MC. Exploring barriers to the use of formal maternal health services and priority areas for action in Sidama zone, southern Ethiopia. *BMC Pregnancy Childbirth*. 2018;18(1):96.
40. Sialubanje C, Massar K, van der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: women's beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;12:61.
41. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynaecol Obstet*. 2010;108:152–3.
42. Tiruneh GT, Taye BW, Karim AM, Betemariam WA, Zemichael F, Wereta TG, et al. Maternity waiting homes in rural health centers of Ethiopia: the situation, women's experiences and challenges. *Ethiop J Heal Dev*. 2016; 30(1):19–28.
43. Sakeah E, McCloskey L, Bernstein J, Yeboah-antwi K, Mills S, Doctor HV. Is there any role for community involvement in the community-based health planning and services skilled delivery program in rural Ghana? *BMC Health Serv Res*. 2014;14:340.
44. Ekirapa-Kiracho E, Namazzi G, Tetui M, Mutebi A, Waiswa P, Oo H, et al. Unlocking community capabilities for improving maternal and newborn health: participatory action research to improve birth preparedness, health facility access, and newborn care in rural Uganda. *BMC Health Serv Res*. 2016;16(Suppl7):638.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions



A3.3. Source of women's household survey questions

Household survey topic	Source
Demographics	Demographic & Health Survey(1)
Education: DEM5, DEM6	W107-109
Literacy: DEM7	W111
Employment: DEM8-DEM9	W912-913
Husband information: DEM14-DEM17	W903-905, 907-908
Asset ownership: DEM21-DEM25	W925, W928, H119-H120
Water sources: DEM26-DEM28	H101, 107-108
Toilet facilities: DEM29	H109
Cooking: DEM30-DEM31	H113-114
Dwelling: DEM32-DEM36, DEM40-DEM50	H116-118, H121-H122, H142-H144
Information sources and decision-making	
Media use: IDM1-IDM3	W113-115
Mobile ownership: IDM4	W116
Decisions: IDM14-IDM20	W919, 921-924
Maternal health care utilization	
ANC: HSU1-HSU3, HSU5-HSU7, HSU9, HSU11	W408-412, 414, 420
Birth: HSU23, HSU17	W429, 430,
PNC: HSU28-HSU29, HSU35-HSU37, HSU39	W436-440, 428
Breastfeeding: HSU44-HSU45	W464-466
Health insurance: DEM46-DEM47	W1109-1110
Malaria-related: DEM39-DEM45	H125-H129, H136-H137
Danger sign knowledge	JHPIEGO BPCR tools (2)
Pregnancy: WDK1-WDK3	301-303
Delivery: WDK5-WDK7	304-305
Postnatal: WDK9-WDK14	306-309
Birth preparedness: HSU21-HSU22	312, 702-704
Attitudes around maternal health care services	
ATT1, ATT3, ATT5-ATT8	401-408
Health facility perceptions	
PHF1, PHF6-PHF9	501-505
Health problems	
Pregnancy: REP17-REP19, REP21	617-618, 620, 621
Delivery: HSU24-HSU25	727-728
Postnatal: HSU31-HSU33	807-808, 811

A3.4. Photographs of upgraded MWHs at selected combined intervention sites

(All photographs included were taken by me during field visits to Ethiopia between 2015 and 2019)



Arrangement of intervention supplies by health centre providers at Lilu Omoti MWH in Seka Chekorsa district.



Study coordinator helping the Lilu Omoti site set up the *injera* stove and ensuring that the chimney was correctly installed.



Sleeping space arranged by health centre providers at Yachi MWH in Gomma district.



Kitchen set up with pots/pans, buckets supplied at Kara Gora MWH, Kersa district



Sleeping area set up by health centre team at Kara Gora MWH, Kersa district



Items for the *buna* ceremony at Kara Gora MWH, Kersa district



Latrines for MWH users at Yachi, Gomma district

Chapter 4. Factors associated with MWH use

A4.1. Construction of the asset-based wealth index

Asset-based wealth indices are an easier way of measuring household wealth in many resource poor settings than using income or expenditure data, which require more resource intense data collection.(3) However, being more an indicator of long-term living standards, the asset-based wealth index is insensitive to short term shocks experienced by families (3) and does not account for quality of assets in its computation.(3) Nevertheless, these indicators have demonstrated acceptable reliability in low-income settings and are commonly used using household surveys such as the Demographic & Health Survey.

An asset-based index for household wealth was calculated using methods described by Vyas and Kumaranayake (3), which relies on principal components analysis (PCA) to generate wealth scores. PCA is a statistical reduction technique that generates a set of unrelated components from a series of many correlated variables. Each component is a “linear weighted combination of the initial variables” and is not correlated to other components; the principal component is the one that has the largest variance as given by eigenvalues. Eigenvalues are associated with eigenvectors which provide weights for each component. The first component is usually used in the index because it explains the largest amount of variation in the data.(3)

Four main steps are outlined in the Vyas method. First, asset variables are selected by examining their means and standard deviations because assets that have the most variation between households have more weight in PCA. A wide range of assets also have to be selected to avoid clustering of households, known as clumping. Truncation, which results in a narrow wealth range and makes distinctions between wealth levels difficult, must also be avoided by selecting assets that will vary across households. Once a selection of variables that best reflect differences between households has been made, PCA is run and the eigen decomposition of the correlation matrix produces a series of principal components (eigenvectors) and their corresponding eigenvalues. Each variable in the principal component has a loading (factor score); positive loadings are usually associated with higher socio-economic status.(3)The selection of variables included in the wealth-index, their means, standard deviations and factor scores are shown in Table A4.1.1.

Table A 4.1.1. Results from principal components analysis

Variable	Mean	Standard deviation	Factor score
Assets owned			
Radio	0.525	0.499	0.1195
Television	0.074	0.261	0.4325
Mobile phone	0.064	0.245	0.2692
Motorbike	0.017	0.130	0.2136
Car/truck	0.004	0.065	0.2090
Number of cows	1.120	1.553	-0.0786
Number of sheep	0.713	1.423	-0.1163
Number of chickens	1.867	2.785	-0.0391
Household water source			
Bore hole	0.027	0.163	-0.0147
Piped source	0.025	0.155	0.3216
Protected spring	0.462	0.499	-0.1328
Protected well	0.079	0.269	0.0117
Public tap/standpipe	0.189	0.392	0.1263
Unprotected source	0.029	0.168	-0.035
Toilet type			
None (use bush)	0.022	0.147	-0.0546
Flush toilet	0.047	0.212	0.0379
Open pit latrine	0.324	0.468	-0.2406
Pit latrine with slab	0.549	0.498	0.1820
Ventilated improved pit latrine	0.057	0.232	0.0949
Dwelling floor material			
Earth/sand	0.906	0.292	-0.2998
Dung	0.065	0.247	0.1639
Brick or cement	0.008	0.092	0.2726
Wood	0.020	0.138	0.1582
Other services			
Electricity	0.272	0.445	0.3664
Health insurance	0.101	0.302	0.1495

Scores can be included in regression models as continuous variables, but this makes parameter estimates hard to interpret. Therefore, the final step is to classify the socio-economic score for each household (computed by using the loadings as weights). Several options exist for classification including “arbitrary or data-driven cut-off points”.⁽³⁾ I used quintiles to classify household wealth similar to the approach adopted by Vyas & Kumaranayake. Internal coherence of the constructed index is assessed by examining the mean value for each variable across wealth quintiles. The results are shown in Table A4.1-2.

Table A 4.1.2. Mean socio-economic scores by quintile

Quintile	n	Score
Poorest	757	-1.456
Second	758	-0.803
Third	755	-0.372
Fourth	757	0.244
Least poor	756	2.391

As shown in Table A4.1-3, ownership of expensive assets, such as televisions and cars, were more common among households in the highest wealth quintile, while ownership of assets such as radios generally increased with household wealth, as expected. Type of water source also varied with household wealth. For instance, piped sources of water were found in households in the least poor quintile, while protected springs were more common to lower socio-economic households. Having health insurance also increased with household wealth.

Table A 4.1.3. Asset ownership and housing characteristics by wealth quintile

Variable	Poorest	Second	Third	Fourth	Least poor
Radio	0.403	0.385	0.612	0.557	0.667
Television	0	0	0	0	0.364
Mobile phone	0	0	0.02	0.06	0.239
Motorbike	0	0	0	0.007	0.078
Car/truck	0	0	0	0	0.021
Number of cows	1.502	1.484	0.974	0.845	0.795
Number of sheep	1.277	1.041	0.503	0.379	0.362
Number of chickens	2.375	2.256	1.632	1.398	1.673
Bore hole	0.033	0.013	0.050	0.019	0.021
Piped source	0	0	0	0	0.123
Protected spring	0.571	0.442	0.568	0.391	0.340
Protected well	0.034	0.067	0.114	0.087	0.091
Public tap/standpipe	0.014	0.128	0.109	0.339	0.353
Unprotected source	0.044	0.025	0.036	0.029	0.011
No toilet facilities	0.687	0.017	0.005	0.013	0.007
Flush toilet	0.003	0.079	0.061	0.042	0.052
Open pit latrine	0.853	0.335	0.139	0.183	0.110
Pit latrine with slab	0.050	0.531	0.752	0.686	0.725
Ventilated improved pit latrine	0.025	0.037	0.042	0.075	0.107
Earth/sand floors	1.0	1.0	0.991	0.897	0.643
Dung floors	0	0	0.009	0.098	0.220
Brick or cement floors	0	0	0	0	0.042
Wood floors	0	0	0	0.003	0.095
Electricity	0	0.08	0.123	0.456	0.689
Health insurance	0	0.060	0.061	0.152	0.220

A4.2. MWH use model with distance instead of travel time

In order to get a sense of the effect of distance on maternity waiting home use in this rural setting, the model presented in Chapter 4 was replicated using straight line distances instead of travel times estimated by women. Travel time estimates may be subject to inaccuracies and incorporate differences in mode of travel between women. While travel time provides insight into both women's perceived and actual accessibility, examining distances calculated using GPS locations can provide additional clarity on the distances at which MWH use is subject to physical accessibility barriers.

Not surprisingly, the proportion of women who reach health centres by foot generally decrease as distance between homes and health centres increases. A slightly higher proportion of women living between two and five kilometres from a health centre reported using some form of transport than those who lived further away (Figure A4.2.1). The use of motorized transport was slightly higher among those belonging to the highest wealth quintiles (14%) than among those who did not (8%) (results not shown).

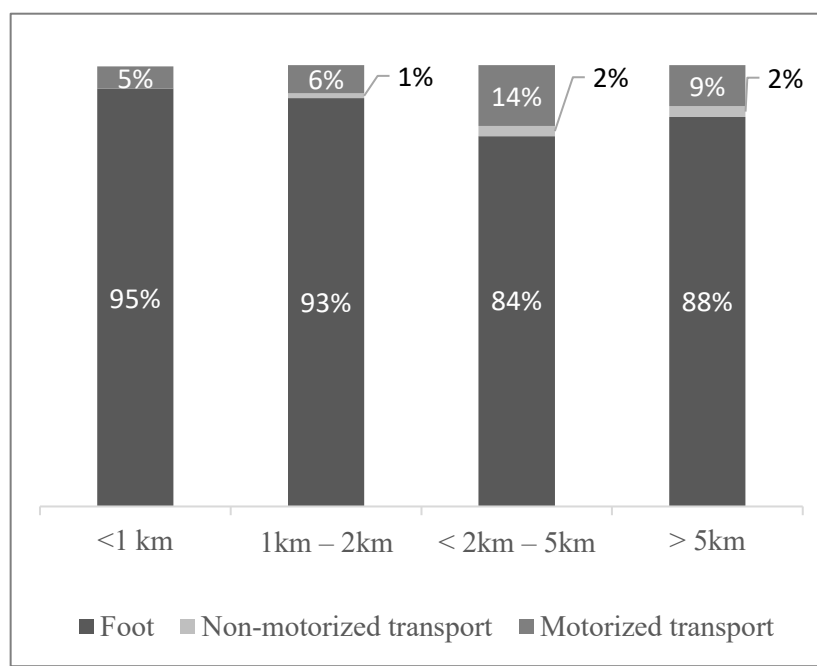


Figure A 4.2.1. Mode of transport used to reach health centre by distance to health centre (n=3,529)

As shown in Table A4.2.1, the associations between MWH use and other factors remain consistent with the model that included travel time (Chapter 4). Being a housewife, having access to companion support and increasing levels of household wealth are associated with higher odds of MWH use. In comparison to women located less than one kilometre from their catchment's health centre where the MWH is located, women living more than five kilometres away had a significantly lower odds of MWH use (odds ratio 0.55, 95% confidence interval: 0.36 to 0.85).

Table A 4.2.1. Results from multivariable random effects logistic regression analysis of MWH use among women in Jimma Zone, Ethiopia (n=3,689) using distance instead of travel time

	Odds Ratio (95% CI)	p-values
INDIVIDUAL LEVEL		
Education		
No formal schooling	1	
Some formal schooling	1.09 (0.83 to 1.45)	0.536
Occupation		
Farmer/trader/other	1	
Housewife	1.69 (1.16 to 2.45)	0.006
HOUSEHOLD LEVEL		
Household wealth		
Poorest	1	
2 nd quintile	1.98 (1.14 to 3.44)	0.016
3 rd quintile	2.61 (1.54 to 4.44)	<0.001
4 th quintile	3.82 (2.28 to 6.40)	<0.001
Least poor	3.08 (1.78 to 5.33)	<0.001
Healthcare decision making		
Never involved	1	
Sometimes involved	0.91 (0.65 to 1.27)	0.582
Always involved	0.57 (0.30 to 1.07)	0.081
Companion for facility visits		
Absent	1	
Present	2.21 (1.46 to 3.34)	<0.001
Distance to health centre within catchment		
< 1 km	1	
1km – 2km	1.21 (0.75 to 1.94)	0.434
> 2km – 5km	0.80 (0.54 to 1.18)	0.258
> 5km	0.55 (0.36 to 0.85)	0.007
COMMUNITY LEVEL		
Community birthing norms	1.00 (0.95 to 1.05)	0.905
COVARIATES		
District of residence		
Gomma	1	
Kersa	0.80 (0.18 to 3.49)	0.768
Seka Chekorsa	0.65 (0.22 to 1.93)	0.441

p-values <0.05 considered statistically significant

MWH, maternity waiting home km, kilometre

The duration of MWH stays also varied by distance with most women reporting less than 24 hours at the MWH living less than five kilometres from the health centre. Contrastingly, 49% of MWH users who used the MWH for at least one week lived more than five kilometers away (results not shown).

A4.3. Opinion piece on MWHs during crisis

A4.3.1 Permission to include publication in thesis from journal editor

RE: Enquiry: Permission to include article in dissertation

Caroline Homer <[REDACTED]>

Thu 10/8/2020 11:25 AM

To: [REDACTED]

Dear Jaameeta

It is fine to include the paper in your thesis. You need to use the accepted word version – not the proofed PDF from the journal. Just reference it and that is fine.

Good luck with you submission. Well done for getting to the end!

Caroline

Professor Caroline Homer

Co-Program Director Maternal, Child and Adolescent Health

Burnet Institute

[REDACTED]

[REDACTED]

Pronouns: she/her

I acknowledge the Traditional Custodians of the land on which Burnet is located, the Boon Wurrung and Wurundjeri people of the Kulin Nations, and recognise their ongoing connection to land, waters and community.

From: [REDACTED]

Sent: Thursday, 8 October 2020 6:46 PM

To: [REDACTED]

Subject: Enquiry: Permission to include article in dissertation

The following enquiry was sent via the Elsevier Journal website:

-- Sender --

First Name: Jaameeta

Last Name: Kurji

Email: [REDACTED]

-- Message --

Dear Dr. Homer,

I recently co-authored an opinion piece with Dr. Kayli Wild that was published in Women and Birth.

The citation details are as follows: Wild K, Kurji J. Maternity waiting homes in times of crisis: Can current models meet women's needs? Women Birth. 2020 Jul 14:S1871-5192(20)30279-1. doi: 10.1016/j.wombi.2020.07.001. Epub ahead of print. PMID: 32680790.

I would like to include a copy of it in my thesis which focuses on maternity waiting home use in Ethiopia. I would be grateful if you could let me know what the procedure is to obtain permission to do so.

Best wishes,
Jaameeta Kurji

A4.3.2 Article citation

Wild K, Kurji J. Maternity waiting homes in times of crisis: Can current models meet women's needs? *Women Birth*. 2020 Jul 14:S1871-5192(20)30279-1. doi: 10.1016/j.wombi.2020.07.001.

A4.3.3 Article content

A4.3.3.1. Article title:

Maternity waiting homes in times of crisis: Can current models meet women's needs?

A4.3.3.2. Authors:

Kayli Wild
Judith Lumley Centre and Institute for Human Security & Social Change, La Trobe University, Australia

Jaameeta Kurji
School of Epidemiology & Public Health, University of Ottawa, Canada

A4.3.3.3. Abstract

Background: Maternity waiting homes (MWHs) located close to birthing facilities are a conditional recommendation by the World Health Organisation, based on very low-quality evidence that they contribute to improvements in maternal or perinatal health outcomes. In addition, several studies suggest that more vulnerable women are less likely to use them. Yet significant investments continue to be made in building and running MWHs within conflict-affected and under-resourced health systems.

Aims: We critically examine the literature to shed light on the challenges and opportunities provided by MWHs during health emergencies and in conflict situations.

Findings and discussion: MWHs are difficult to utilise during crises because they require women to be away from home, are often designed as dormitories, can lack security and be over-crowded. Some MWHs have been adapted during situations of political conflict to incorporate birthing and broader reproductive health care, thereby improving the availability of care away from over-burdened health facilities. How MWHs are adapted during times of crisis may provide insights into what systems of care are more appropriate in meeting women's needs more broadly.

Conclusion: The current global pandemic is an important time to reflect on whether MWHs are meeting the needs of a diverse range of women, in times of stability and during emergencies, and engage in

genuine dialogue with women about the kinds of maternity care they want. We need to co-create those systems now so that they are more resilient during the inevitable crises we will face in the future.

A4.3.3.4. Statement of significance

Problem: MWHs are often implemented in ‘fragile’ states. Given their resurgence as a strategy in under-resourced health systems it is important to understand how they are affected during crisis situations such as pandemics and political conflict.

What is already known: During times of stability there are significant barriers for women in utilising MWHs and studies show these barriers are heightened for more vulnerable women. The communal design of many MWHs and the fact they require women to be away from home for long periods, means they pose additional access barriers during emergencies.

What this paper adds: Experience from previous crisis situations suggests that if a wider range of reproductive health services were incorporated within MWHs they could be more useful in improving health infrastructure and the availability of care. This should prompt us to reflect on whether MWHs are an appropriate strategy and what other models of care would be better able to meet women’s needs during crises and in regular programming.

A4.3.3.5. Introduction

Maternity waiting homes (MWHs) are lodgings, located near health facilities with obstetric care, to house pregnant women close to term. They are used with the aim of increasing access to facility-based birth for women with high-risk pregnancies or those who live in remote areas.(1,2) They are most frequently implemented in low- and middle-income countries, but also in high-income countries for women in remote areas, including for Indigenous women in Australia and Canada. In some instances, they have been used as a direct response to a political crisis and population displacement.(3,4) Elsewhere, they have been implemented in ‘fragile states’(5), such as Afghanistan, Ethiopia and Timor-Leste(1,6) with weak or disrupted health systems and that contribute appreciably to the global burden of maternal mortality.(7)

During crises, such as the current COVID-19 pandemic, barriers to accessing maternal and reproductive services are amplified as people’s ability to move around is limited, families have less resources, social cohesion is impacted and health systems become overwhelmed.(8) During the 2014 Ebola epidemics, for example, there were significant reductions in the utilisation of facility-based maternity services,(9,10) including MWH stays.(11) These findings are not unexpected, but they are concerning in contexts where women already have limited access to these services. In this paper we examine the literature on MWHs during times of stability and in crisis situations. The aim is to highlight

the challenges and opportunities of MWHs and stimulate discussion about whether they are an appropriate strategy for meeting women's needs.

A4.3.3.6. Findings and discussion

Evidence of the effectiveness of MWHs is mixed. In particular, there is insufficient evidence that MWHs improve maternal and neonatal morbidity and mortality,(12,13) or that they facilitate access to maternal healthcare services for women in diverse contexts, particularly in crisis situations.(3,11,14) There is consensus, however, that if MWHs are to be implemented they need to be embedded within a broader system providing quality maternal health care, including availability of equipment and essential medicines, adequate human resources, respectful care, provision of life-saving emergency obstetric care and timely referral.(1,6,12,15,16)

Studies continue to highlight the issues women face in using MWHs, such as indirect costs associated with transport and food, living in remote areas, and being away from family.(17–19) Some studies have shed light on the lower utilisation by more marginalised women such as those who are unmarried(20), belong to Indigenous minorities(21) or lack social support and are poor(22) although this is highly context-dependent.(23) Importantly, the ability of some of the most vulnerable women to access MWHs, such as those who have a disability or are being subjected to violence at home, remains unknown. Utilising MWHs during times of stability, therefore, presents many challenges for women and the strategy may be particularly ill-suited to women's needs during times of crisis. For example, MWHs are often designed as dormitories (21,24–26) and can be over-crowded (24,27). This means their use would not be recommended during outbreaks such as the Ebola epidemic or the COVID-19 pandemic due to the risk of infection in close quarters. The reported lack of security (28,29) means they are also ill-suited during times of conflict or political instability. Women have described the insufficient monitoring by midwives as a reason for not using MWHs (29–32), which can be further impacted when health systems are at capacity or the safety of health providers is at risk. Women commonly need someone to accompany them, often another woman, to organise food and clean water for them during their stay.(22,30,33) Being far from home is more difficult during health crises as women may be more reluctant to leave their children, or need to take on the additional burden of caring for family members who are ill. This highlights the “gendered impact”(34) of crisis situations such as the COVID-19 pandemic, where women are additionally disadvantaged due to their higher level of need for reproductive health services and in their dual roles as caregivers and workers.(35) At the national level, maternal health systems in countries that receive substantial external funding may be particularly vulnerable during crises that result in reallocation of resources to fighting pandemics or substantially reduced foreign aid. In many countries that currently operate MWHs, donor funds represent more than one-fifth of health spending.(36)

On the other hand, MWHs may provide unique opportunities for health systems to adapt to provide better services for women, including during crises. Many have been constructed as separate buildings and could be used to provide a broader range of maternal health services away from other sick patients. There are some examples of MWHs that have incorporated antenatal, birth and postnatal services during situations of political conflict (4,37), therefore they have functioned more as birth centres. During epidemics, natural disasters and violent conflicts, tertiary level referral services are often the most severely affected. Maintaining decentralised maternal and reproductive health services, and rapidly adapting these to meet the needs of local populations is critical for maintaining access to services, particularly given that populations tend to return to their home districts in times of crisis.(3)

Other models, such as midwifery continuity of care (38) - which involves care from a known midwife throughout pregnancy, birth and postnatally - have strong evidence (39) but have seldom been tried in low-income countries or conflict-affected settings. It has been mentioned previously that because MWHs are visible structures that promote the ideology of facility-based birth that they may more closely reflect the interests of government officials and donors rather than the needs of women.(40) We argue that there should be more debate about the feasibility and appropriateness of investing in MWHs relative to more systems-focused improvements such as decentralising and linking levels of maternity care, and increasing continuity and quality of care.

A4.3.3.7. Conclusion

An examination of the limitations and potential of MWHs in times of crisis highlights the gendered impact of emergencies and how difficult it is for women to stay away from their family before birth. The pragmatic adaptation of MWHs, however, could serve women better if they help improve maternal health infrastructure and resourcing, provide a place for birthing away from sick patients, incorporate a broader range of antenatal, birth and postnatal care, and help in maintaining decentralised reproductive health services. Therefore, instead of diverting attention and resources away from these broader health system improvements, MWHs could be transformed to include these essential components of care. The current COVID-19 pandemic presents an opportunity to reflect, together with governments, civil society, and a diversity of women, on whether MWHs are an appropriate woman-centred strategy, and how we can invest in maternal health systems that are better able to meet women's needs in times of stability and in future emergencies.

“It's only when diverse perspectives are included, respected, and valued that we can start to get a full picture of the world, who we serve, what they need and how to successfully meet people where they are”.(41)

A4.3.3.8. Article References

1. World Health Organization. Maternity Waiting Homes: A review of experiences. Geneva; 1996.
2. Lawson J, Stewart D, editors. The organization of obstetric services. In: Obstetric and gynaecology in the tropics and developing countries. London: Edward Arnold Publishers Ltd; 1967.
3. Wayte K, Zwi AB, Belton S, Martins J, Martins N, Whelan A, et al. Conflict and Development: Challenges in Responding to Sexual and Reproductive Health Needs in Timor-Leste. *Reprod Health Matters*. 2008;16(31):83–92.
4. UNFPA. A safe haven for pregnant women in Somalia [Internet]. 2015 [cited 2020 May 1]. Available from: <https://www.unfpa.org/news/safe-haven-pregnant-women-somalia>
5. OECD. States of Fragility 2018. Paris; 2018.
6. Das J, Akseer N, Mirzazada S, Peera Z, Noorzada O, Armstrong CE, et al. Scaling up primary health services for improving reproductive, maternal, and child health: a multisectoral collaboration in the conflict setting of Afghanistan. *BMJ*. 2018;363(k4986).
7. World Health Organization. Maternal mortality [Internet]. 2019 [cited 2020 Apr 24]. Available from: <https://www.who.int/news-room/fact-sheets/detail/maternal-mortality>
8. Rohwerder B. Secondary impacts of major disease outbreaks in low- and middle- income countries. 2020.
9. Delamou A, Ayadi AM El, Sidibe S, Delvaux T, Camara BS, Sandouno SD, et al. Effect of Ebola virus disease on maternal and child health services in Guinea:a retrospective observational cohort study. *Lancet Glob Heal*. 2017;5:e448-57.
10. Jones SA, Gopalakrishnan S, Ameh CA, White S, van den Broek N. ‘Women and babies are dying but not of Ebola’:the effect of the Ebola virus epidemic on the availability , uptake and outcomes of maternal and newborn health services in Sierra Leone. *BMJ Glob Heal*. 2016;1(e000065).
11. Lori JR, Rominski SD, Perosky JE, Munro ML, Williams G, Bell SA, et al. A case series study on the effect of Ebola on facility-based deliveries in rural Liberia. *BMC Pregnancy Childbirth*. 2015;15(254).
12. World Health Organization. WHO Recommendations on health promotion interventions for maternal and newborn health. Geneva, Switzerland; 2015.
13. van Lonkhuijzen L, Stekelenburg J, van Roosmalen J. Maternity waiting facilities for improving maternal and neonatal outcome in low-resource countries. *Cochrane database Syst Rev*. 2012;10:CD006759.
14. Perosky JE, McLean K, Kofa A, Nyanplu A, Munro-Kramer ML, Lori JR. Utilization of maternity waiting homes: before , during , and after the Ebola virus disease outbreak in Bong County , Liberia. *Int Health*. 2020;12:69–71.
15. Lori JR, Perosky J, Munro-Kramer ML, Veliz P, Musonda G, Kaunda J, et al. Maternity waiting homes as part of a comprehensive approach to maternal and newborn care: a cross-sectional survey. *BMC Pregnancy Childbirth*. 2019;19(228).
16. Koblinsky M, Moyer CA, Calvert C, Campbell J, Campbell OMR, Feigl AB, et al. Quality maternity care for every woman, everywhere: a call to action. *Lancet*. 2016;388(10057):2307–20.
17. Vermeiden T, Schiffer R, Langhorst J, Klappe N, Asera W, Getnet G, et al. Facilitators for maternity waiting home utilisation at Attat Hospital: a mixed-methods study based on 45 years of experience. *Trop Med Int Heal*. 2018;23(12):1332–41.
18. Getachew B, Liabsuetrakul T. Health care expenditure for delivery care between maternity waiting home users and nonusers in Ethiopia. *Int J Heal Plan Manag*. 2019;34:e1334–45.

19. Sialubanje C, Massar K, Van Der Pijl MSG, Kirch EM, Hamer DH, Ruiter RAC. Improving access to skilled facility-based delivery services: Women's beliefs on facilitators and barriers to the utilisation of maternity waiting homes in rural Zambia. *Reprod Health*. 2015;
20. Lori JR, Boyd CJ, Id MLM, Veliz PT, Id GH, Kaiser J, et al. Characteristics of maternity waiting homes and the women who use them: Findings from a baseline cross-sectional household survey among SMGL-supported districts in Zambia. 2018;1–13.
21. Ruiz MJ, van Dijk MG, Berdichevsky K, Munguía A, Burks C, García SG. Barriers to the use of maternity waiting homes in indigenous regions of Guatemala: A study of users' and community members' perceptions. *Cult Heal Sex*. 2013;15(2):205–18.
22. Kurji J, Gebretsadik LA, Wordofa MA, Sudhakar M, Asefa Y, Kiros G, et al. Factors associated with maternity waiting home use among women in Jimma Zone, Ethiopia: a multilevel cross-sectional analysis. *BMJ Open*. 2019;9(e028210).
23. Fogliati P, Straneo M, Mangi S, Azzimonti G, Kisika F, Putoto G. A new use for an old tool: Maternity waiting homes to improve equity in rural childbirth care. Results from a cross-sectional hospital and community survey in Tanzania. *Health Policy Plan*. 2017;32(10):1354–60.
24. Bonawitz R, Mcglasson KL, Kaiser JL, Ngoma T, Fong RM, Biemba G, et al. Quality and utilization patterns of maternity waiting homes at referral facilities in rural Zambia: A mixed-methods multiple case analysis of intervention and standard of care sites. *PLoS One*. 2019;14(11):e0225523.
25. Shrestha SD, Rajendra PK, Shrestha N. Feasibility study on establishing Maternity Waiting Homes in remote areas of Nepal. *Reg Heal Forum*. 2007;11(2).
26. World Health Organization. Namibia: Maternity waiting homes protect newborns and mothers [Internet]. 2016 [cited 2020 May 1]. Available from: <https://www.who.int/news-room/feature-stories/detail/namibia-maternity-waiting-homes-protect-newborns-and-mothers>
27. van den Heuvel OA, de Mey W, Buddingh H, Bots M. Use of maternal care in a rural area of Zimbabwe: A population-based study. *Acta Obstet Gynecol Scand*. 1999;78:838–46.
28. Chibuye PS, Bazant ES, Wallon M, Rao N, Fruhauf T. Experiences with and expectations of maternity waiting homes in Luapula Province, Zambia: a mixed – methods, cross-sectional study with women, community groups and stakeholders. *BMC Pregnancy Childbirth*. 2018;18(42).
29. Suwedi-Kapesa L, Nyondo-Mipando A. Assessment of the quality of care in Maternity Waiting Homes (MWHs) in Mulanje District, Malawi. *Malawi Med J*. 2018;2:103–10.
30. Gaym A, Pearson L, Soe KWW. Maternity waiting homes in Ethiopia-three decades experience. *Ethiop Med J*. 2012;50(3):209–19.
31. Mramba L, Nassir FA, Ondieki C, Kimanga D. Reasons for low utilization of a maternity waiting home in rural Kenya. *Int J Gynecol Obstet*. 2010;108(2):152–3.
32. Wilson JB, Collison AH, Richardson D, Kwofie G, Senah KA, Tinkorang EK. The maternity waiting home concept: the Nsawam, Ghana experience. The Accra PMM Team. *Int J Gynaecol Obstet*. 1997 Nov;59 Suppl 2:S165-72.
33. Bergen N, Abebe L, Asfaw S, Kiros G, Kulkarni MA. Maternity waiting areas – serving all women? Barriers and enablers of an equity-oriented maternal health intervention in Jimma Zone, Ethiopia. *Glob Public Health*. 2019;14(10):1509–23.
34. Wenham C, Smith J, Morgan R. COVID-19 : the gendered impacts of the outbreak. *Lancet*. 2020;395:846–8.
35. Hussein J. COVID-19: What implications for sexual and reproductive health and rights globally? *Sex Reprod Heal Matters*. 2020;28(1).
36. World Health Organization. Global Spending on Health: A World in Transition 2019. Geneva; 2019.

37. Wild K, Barclay L, Kelly P, Martins N. The tyranny of distance: maternity waiting homes and access to birthing facilities in rural Timor-Leste. *Bull World Heal Organ*. 2012;90:97–103.
38. World Health Organization. WHO recommendation on midwife-led continuity of care during pregnancy [Internet]. 2016 [cited 2020 May 1]. Available from: <https://extranet.who.int/rhl/topics/improving-health-system-performance/implementation-strategies/who-recommendation-midwife-led-continuity-care-during-pregnancy>
39. Sandall J, Soltani H, Gates S, Shennan A, Devane D. Midwife-led continuity models versus other models of care for childbearing women (Review). *Cochrane Database Syst Rev*. 2016;(4).
40. Wild K, Kelly P, Barclay L, Martins N. Agenda Setting and Evidence in Maternal Health: Connecting Research and Policy in Timor-Leste. *Front Public Heal*. 2015;3(September):1–9.
41. Brown B. *Dare to Lead*. New York: Random House; 2018.

Appendix Four References

1. Demographic and Health Surveys: Model Woman's Questionnaire. <https://dhsprogram.com/publications/publication-dhsq7-dhs-questionnaires-and-manuals.cfm>; 2016.
2. JHPIEGO. Monitoring birth preparedness and complication readiness. Tools and indicators for maternal and newborn health. Baltimore; 2004.
3. Vyas S, Kumaranayake L. Constructing socio-economic status indices: How to use principal components analysis. *Health Policy Plan*. 2006;21(6):459–68.

Chapter 7. Evaluation of MWHs⁺ and local leader training

A7.1. Ancillary analysis methods

A7.1.1 Framework for investigating trial results

Additional descriptive analyses were carried out primarily using endline household survey data to explore reasons why the interventions did not increase institutional births to the extent expected. Using frequency tables, descriptive statistics and graphs, the data were examined using the conceptual framework created in Figure A7.1.1 as a guide to begin to explore possible explanations for the results. It is important to note that no causal inferences can be made, as indicators are only proxies and limited by their cross-sectional nature. Rather these analyses are meant to provide some insight into areas that require in-depth exploration using project monitoring and qualitative data. Sample sizes, particularly for MWH users, are very small and any results need to be interpreted with caution.

As described earlier, the interventions were hypothesized to improve delivery care use in two ways: (i) MWHs⁺ were expected to provide pregnant women in the combined arm experiencing physical access barriers a comfortable, midwife-monitored place to stay at the health centre which they were expected to access through appropriate referral by HEWs and/or midwives; (ii) leader training was anticipated to create an enabling environment for women in both intervention arms by improving community awareness of the importance of maternal healthcare services as well as mobilizing families and the community to support women in overcoming barriers in accessing these services. While awareness about MWHs was expected to increase in both the interventions arms, MWH use was anticipated to be highest in the MWH⁺ & training arm where upgraded, functional MWHs were available and where women were actively linked by midwives or HEWs associated with the intervention health centres.

The smaller than expected increase in the levels of delivery care use in the intervention arms could have been due to low exposure to the interventions as a result of poor intervention delivery or suboptimal participant responsiveness, which would dilute intervention effect (Figure A7.1.1). Alternatively, the interventions as designed may have been ineffective if women still experienced physical accessibility issues, lacked social support or the interventions did not address women's needs in terms of distance or quality of care.

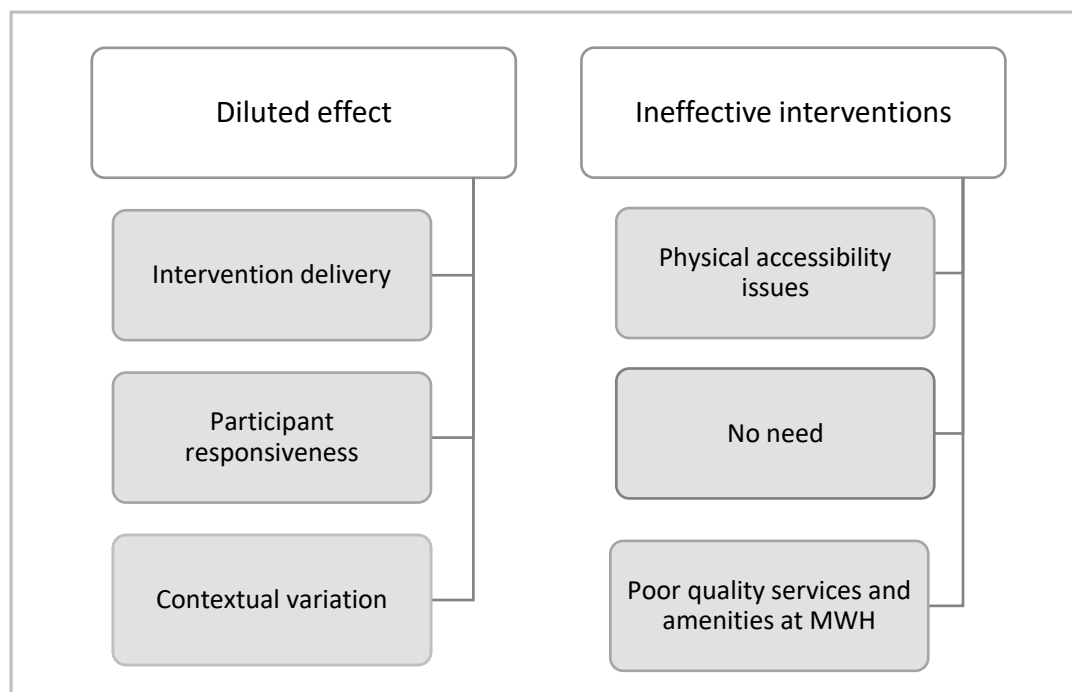


Figure A.7.1.1. Conceptual framework outlining potential reasons for non-significant intervention effects

While a comprehensive assessment of implementation fidelity was out of the scope of my thesis, I drew on fidelity literature to guide preliminary exploratory analysis to understand the trial findings. Implementation fidelity is defined as the “extent to which delivery of an intervention” proceeds “as intended”.(1,2) Process evaluations, which can include anything from simple descriptive analyses to in-depth mixed methods studies, can be used to understand implementation, explore how context may give rise to outcome variation and assist with result interpretation.(3) Implementation fidelity and contextual factors that affect implementation have been described as important factors influencing observed outcomes (4,5) while poor implementation has been speculated to lead to erroneous conclusions about intervention effectiveness.(6) Therefore, exploring some aspects of implementation and contextual variation is important to begin to understand reasons for observed results.

A7.1.2 Indicators used for exploratory analysis

The indicators used for the post-hoc exploratory analysis to understand the trial findings are listed in Table A7.1.1. The extent of intervention delivery related to MWHs was assessed by examining awareness about MWH services and benefits while the quality of MWH⁺ delivery was judged by looking at what services were available to users at endline. Women’s sources of health-related information and contact with HEWs through home visits were inspected to gain insight into the extent to which women may have been engaged by local leaders (religious leaders and WDA and health workers (HEWs and midwives) in the combined intervention arm as this was a prerequisite for increased

Table A 7.1.1. Summary of indicators explored under intervention delivery, participant responsiveness, contextual variation and quality using endline survey data

Area of interest	Indicators
Extent of intervention delivery	Proportion of women aware of the existence of MWHs across trial arms and by distance to health centre
	Proportion of women aware of the various benefits of MWH use across trial arms
	Proportion of women who report not using an MWH because of a lack of awareness of MWHs by trial arm and distance to health centre
	Proportion of women who report HEWs as a source of health-related information by trial arms endline
	Proportion of women who report midwives as a source of health-related information by trial arms
	Proportion of women who report WDA as a source of health-related information by trial arms
	Proportion of women who report religious leaders as a source of health-related information by trial arms
	Proportion of women reporting home visits by HEWs by trial arms
	Proportion of women who report Development Army or religious leaders as sources of practical support during their last pregnancy
	Proportion of women who list MWH use as counselling topic during ANC visits for their last pregnancy
	Proportion of MWH users who report having access to or receiving: (i) beds/bedding, (ii) food/cooking facilities, (iii) clean water, (iv) latrines, (v) bathing areas, (vi) electricity/power source and (vii) midwife checks during their stay.
Participant responsiveness to MWH intervention component	Proportion of women who reported using an MWH by trial arm
	Proportion of women who report securing an MWH referral as part of their birth preparedness and complication readiness plan by trial arm and by distance to health centre
	Proportion of MWH users who report using an MWH because of large distances between home and health facility as reason for staying at the MWH
	Proportion of MWH users who report using an MWH because of expecting complications as reason for staying at the MWH
Contextual variation, accessibility and needs	Proportion of women who delivered their last child at home or en route to a health facility by PHCU
	PHCU-level differences in straight-line distances between homes and catchment health centre
	Proportion of women who did not give birth at a health facility because of transport constraints by PHCU
	Proportion of women who did not give birth at a health facility because of large distances between home and health facility
	Proportion of households that own a mobile phone by PHCU and trial arm

Area of interest	Indicators
	Proportion of women who are members of a social or community group
	Proportion of women who reported participating in programs of activities aimed at promoting maternal healthcare service use

use of the upgraded MWHs. Women's sources of practical support were also examined to see if local leaders at endline were among providers of practical help as this might be an indication of leaders' activities to support women's access to care.

The receipt of the intervention by women or "participant responsiveness" refers to how well or how much participants "respond to or are engaged by an intervention". It represents one of the elements of implementation fidelity.(2) This was gauged through levels of MWH use; women integrating MWH use into their birth preparedness plans by securing MWH referrals was also used as a proxy indicator for participant responsiveness. MWH users' reasons for use were also examined to see what proportion chose to use an MWH because they complied with a referral and/or accepted that staying there addressed the distance or risk of complication concerns.

Although limited analyses on contextual variation was possible using survey data, PHCU-level differences within trial arms were compared graphically and using chi square tests where appropriate. Distances between homes and catchment health centres provided an indication of physical accessibility. The proportion of women who did not give birth at a health facility because of transport constraints and large distances was also examined. Mobile telephone ownership was compared between PHCUs as this might be an indication women's ability to connect with HEWs and call for ambulances as is routine practice in this setting among women who go into labour but have no transport. The extent of membership in community and social groups as well as participation in maternal and child health programs/initiatives was also inspected to have a sense of how connected women in the different PHCUs were with social structures as these form potential platforms through which leader activities are delivered.

It is also possible that no effect was detected because the interventions as designed were actually not effective. With respect to MWHs⁺, one of the reasons could be that pregnant women still experienced physical access barriers i.e., it was difficult to get to MWHs because of transport constraints, high costs or prohibitive distances. To investigate this, the reasons for not using MWHs among women were examined. Need for the MWHs (as perceived by women) was assessed using the proportion of women who reported not using an MWH because they lived close to a health facility.

A7.2. Ancillary analysis results¹

A7.2.1 Extent of intervention delivery

A7.2.1.1. *Awareness of the existence of MWHs*

The proportion of women at endline who had heard of MWHs was the same across all three trial arms (~56%). When awareness levels across the three arms were stratified by distance, a slightly higher percentage of women living closer to health centres had heard about MWHs in the combined intervention arm compared to the other arms (Figure A7.2.1.1), but these differences were not statistically significant (cluster-adjusted χ^2 (<1km) = 0.78, p=0.676; cluster-adjusted χ^2 (1km-2km) = 1.49, p=0.474).

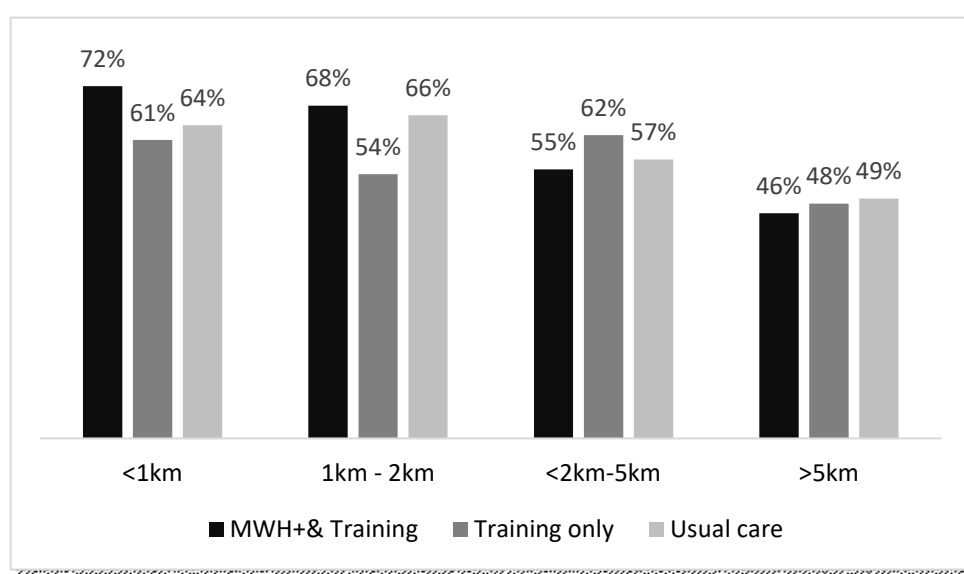


Figure A.7.2.1. Percentage of women aware of MWHs by trial arm and distance to health centre (n=3,809 women)

Within a kilometre of the health centre, a higher proportion of women in the combined intervention arm knew of MWH users compared to the other arms but for larger distances up to five kilometres women in usual care seemed to be more familiar with someone who had used an MWH (Figure A7.2.2). None of these differences were statistically significant. GPS locations of health posts were not collected making it impossible to explore how awareness was affected by proximity to HEWs.

¹ The results presented here include those not reported in the published trial paper (Chapter 7) due to space restrictions, but help to discuss and put all thesis findings into context.

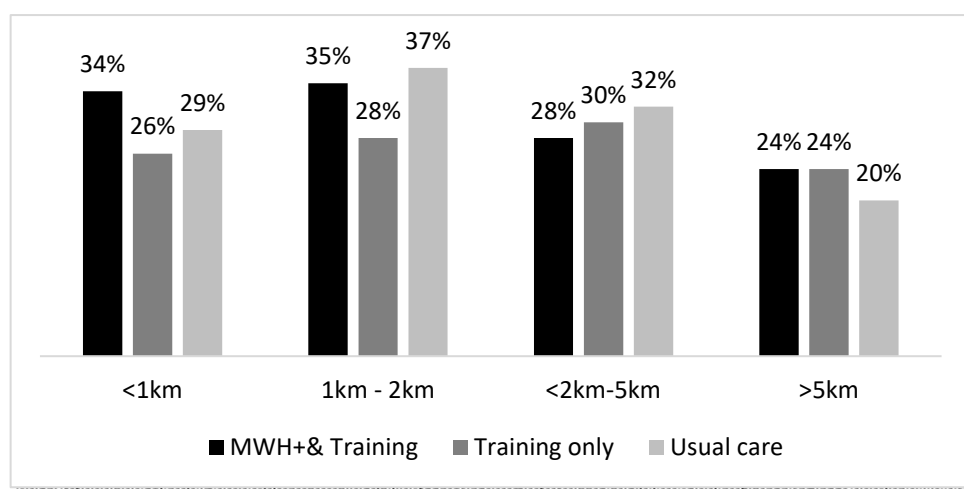


Figure A7.2.2. Percentage of women aware of MWH user by trial arm and distance to health centre (n=3,809 women)

A7.2.1.2. Awareness of the benefits of MWH stay

Overall, at endline 37% of women reported not knowing what benefits MWH stay offered; however, this is not surprising as most of these women had never heard of MWHs to begin with. The most common response about advantages of stay was related to the fact that MWHs facilitated access to delivery and postnatal care and helped to detect and manage complications² (Figure A7.2.3). This was followed by MWHs provide an opportunity for pregnant women to rest. Responses did not differ much by trial arm.

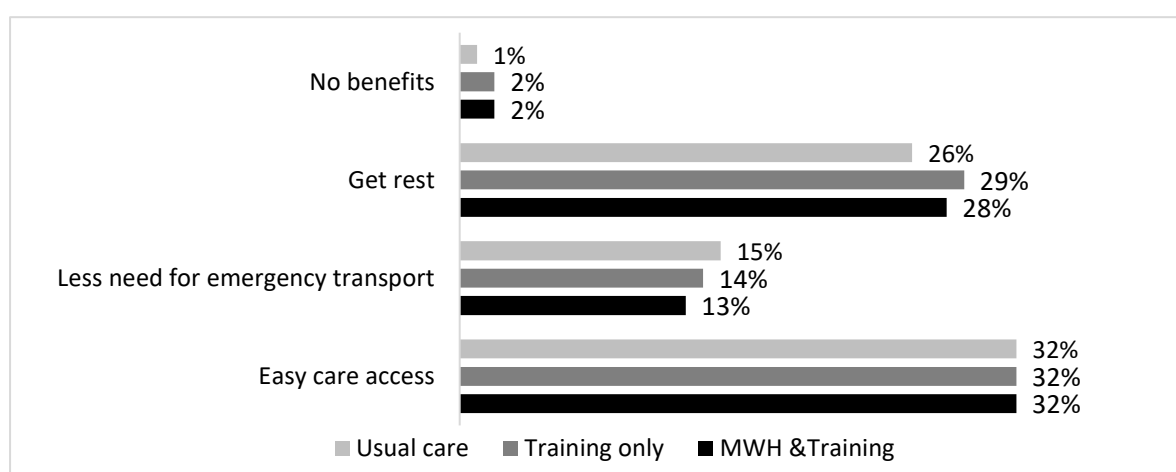


Figure A.7.2.3. Percentage of most common responses by trial arm provided by women about benefits of MWH stay excluding those unaware about benefits (n=4,358 responses). Multiple responses possible

² Other responses related to the idea of access to skilled care including “for safe delivery” or “for the health of the mother” or “for the health of the mother and baby” “prevent bleeding” were reclassified under this response category. This approach may overestimate women’s ability to identify specific benefits of MWH stay as without using open-ended questions to probe exactly how women thought MWHs would help protect the health of women and/or babies, it is impossible to determine whether or not their responses accurately reflect MWH benefits. Responses provided under the “Other” category that were not reclassified included: “able to get food”, “prevent home delivery”,

A7.2.1.3. Reasons for never having used an MWH

About 94% (n=3,590) of women at endline had never used MWH services. A lack of familiarity with the service was the most common response for non-use (n=1,434 responses, 32%). The percentage of women who had never used an MWH for this reason progressively increased with distance from the health centre across all three arms (Figure. A7.2.4).

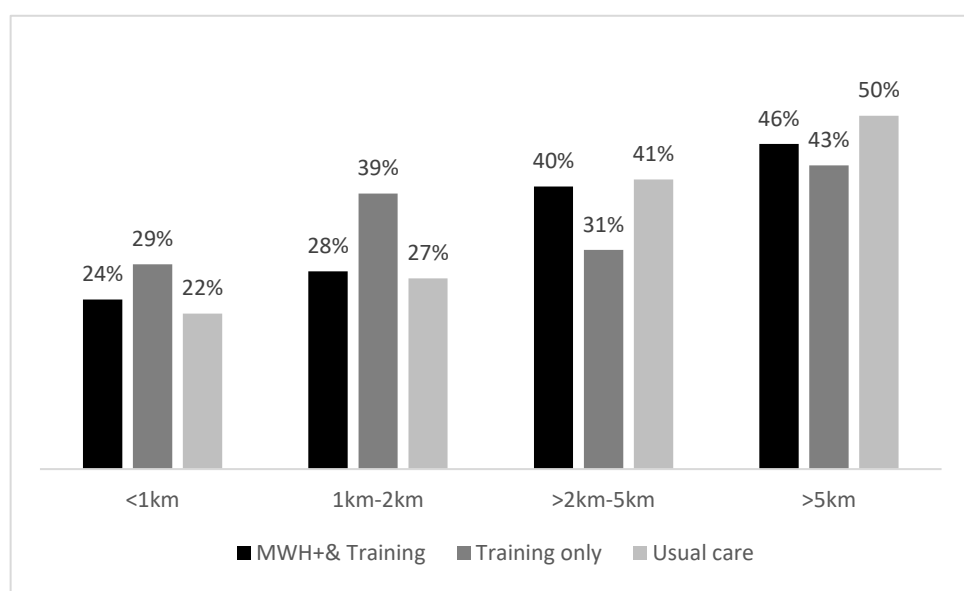


Figure A7.2.4. Percentage of women never having used MWHs due to unfamiliarity with services by trial arm and distance to health centre (n=3,590 women)

Among women who had heard of MWHs, however, living close enough to a health facility was the most common reason provided for never having used MWH services (n=827 responses, 33%) followed by concerns about the quality of services offered (n=326 responses, 13%). Other responses such as not having childcare (n=120 responses, 5%), constraints related to domestic responsibilities (n=30, 1%) or not having family approval (n=50 responses, 2%) were not frequently mentioned.

Interestingly, women who said that they were close enough to a health facility not to need MWH services lived an average of 2.4 kilometres (range 300 metres to 14.5 kilometres) from their catchment health centre. Many of the women that provided this response resided in Gomma district PHCUs where a higher proportion of women belong to wealthier quintiles (Gomma: 34%, Seka Chekorsa: 12%, Kersa: 9%) and differences in wealth between districts was statistically significant (cluster-adjusted χ^2 : 16.6, $p=0.03$).

When responses were examined by trial arm, they largely followed the same patterns with living close to a health centre being a slightly higher reason for non-use in the training only arm (Figure

A.7.2.5). The differences between trial arms on distance-based need (cluster-adjusted $\chi^2=3.60$, $p=0.165$), lack of referrals (cluster-adjusted $\chi^2=0.98$, $p=0.614$) and service quality concerns (cluster-adjusted $\chi^2=3.92$, $p=0.141$) were not statistically significant.

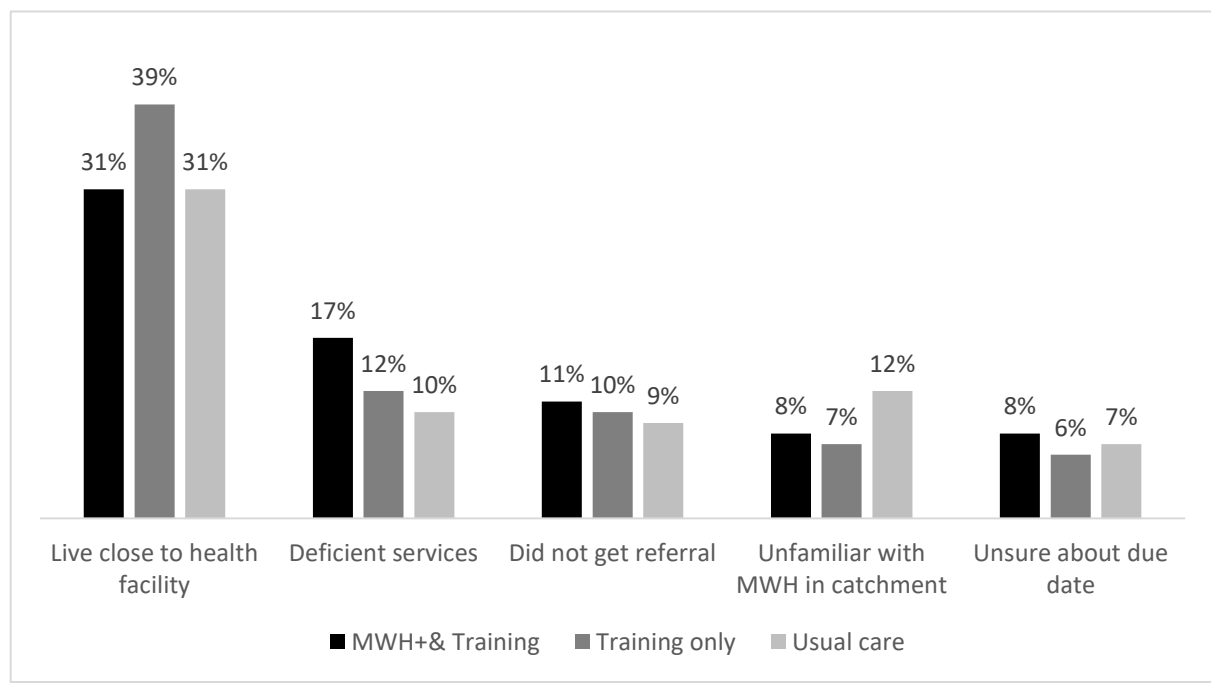


Figure A7.2-5. Most common reasons for non-use of MWHs among women aware about them by trial arm (n=2,508 responses). Multiple responses possible

A7.2.1.4. MWH services received by users

While 6% of women at endline reported ever staying at MWH, only 3% (n=112) used the services during their most recent pregnancy with no significant differences between trial arms. Most users reported having access to bedding at MWHs across all three arms (Figure A7.2.6). It was surprising to discover that only 14% of users in the combined intervention arm reported having access to items for the coffee ceremony despite distribution of supplies to these sites. Less than a quarter of users at MWHs⁺ reported the presence of clean water or sources of power. Midwife monitoring of MWH users was also lowest in the combined intervention arm. MWH users in this arm also had the least access to toilet and bathroom facilities. These are notable deficiencies in services expected of MWHs⁺ and likely impacted utilization of services in this arm.

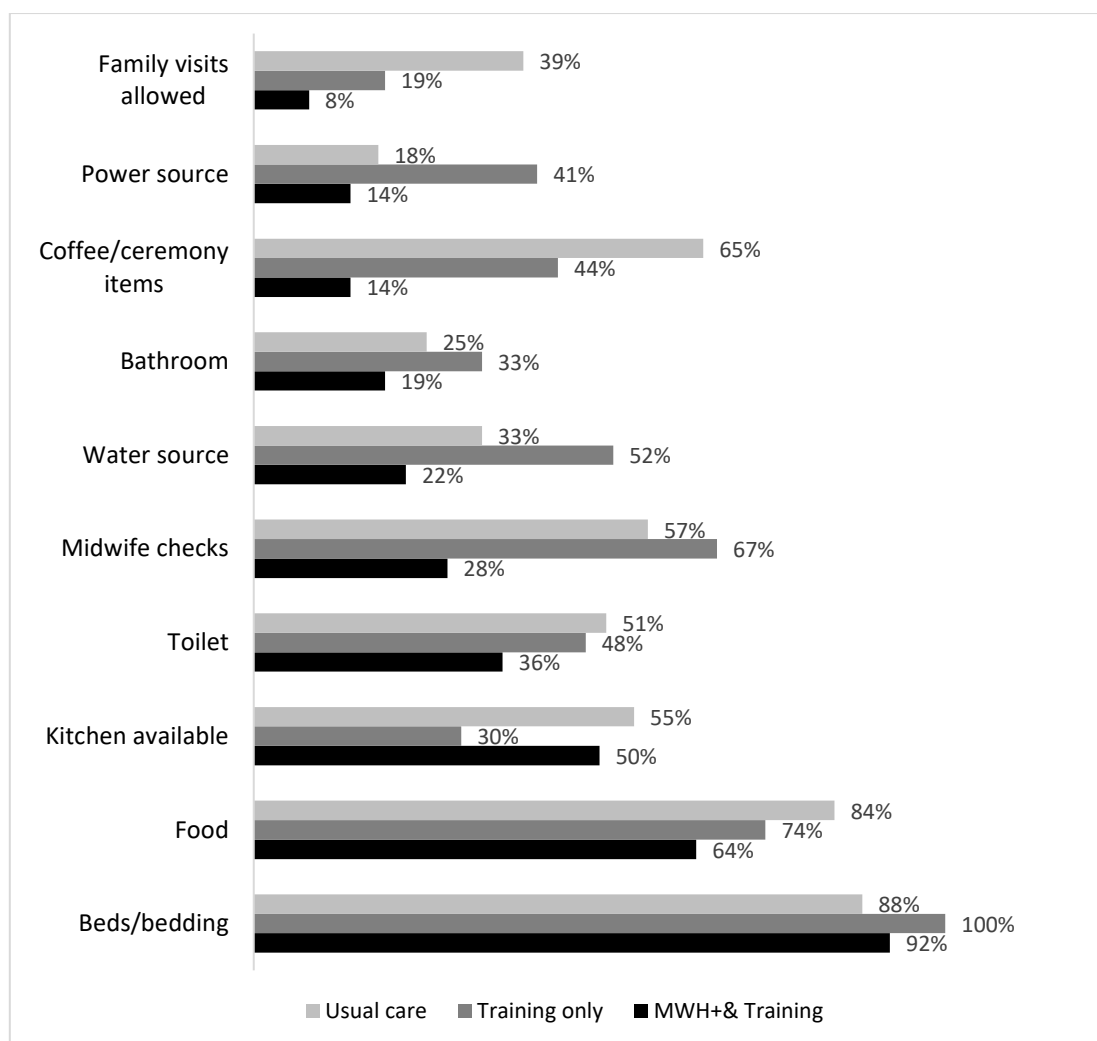


Figure A7.2.6. Percentage of services received by MWH users during most recent stay (n=112 women)

A7.2.1.5. Intervention providers as sources of women's health information

Across all three arms, HEWs and nurses were the most common sources health-related women for women followed by the radio (Figure A7.2.7). Members of the Development Army were very rarely cited as sources of health information (n=37 responses, <1%) and religious leaders were not mentioned at all. About 4% (n=160) of the women interviewed at endline indicated that they were part of the WDA, the majority of whom identified themselves as WDA leaders (n=107).

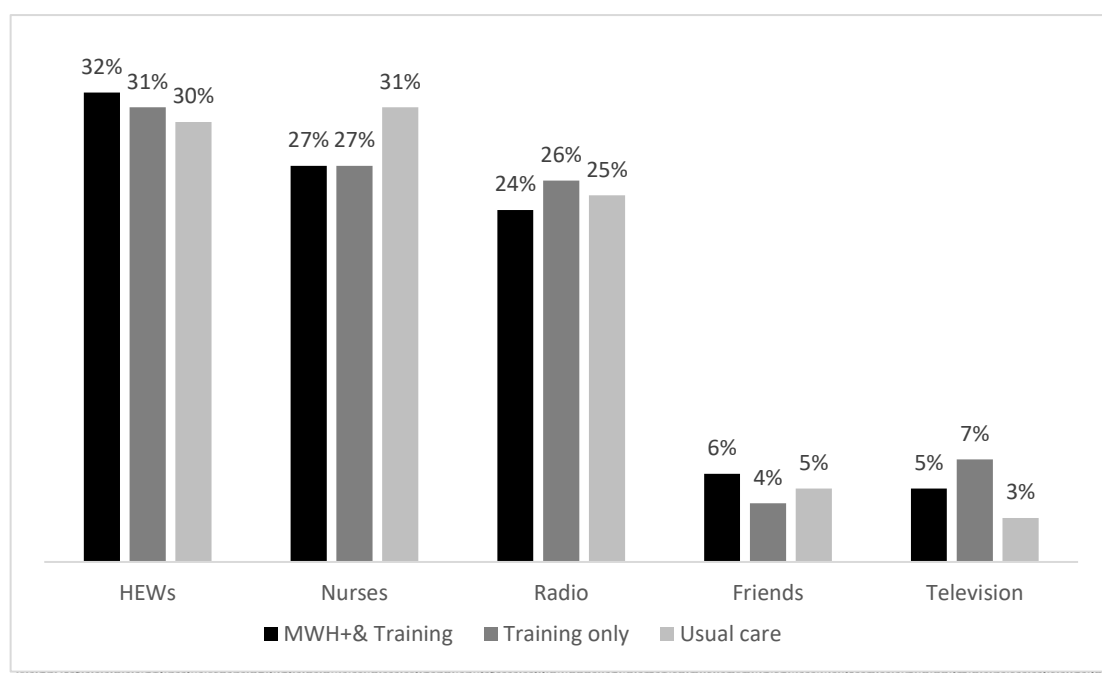


Figure A7.2-7. Sources of health-related information by trial arm (n=6,906 responses). Multiple responses possible

A7.2.1.6. Other proxy indicators of engagement with intervention providers

About one-third of women reported ever receiving a home visit from an HEW with no difference between trial arms. In terms of frequency of visits, most described being visited less than once a month with a slightly higher percentage of women in the intervention arms (MWH⁺ & training=100, 23%; training only: n=91, 22%) getting one to two visits compared to usual care (n=66, 17%). The differences in frequency of visits were not statistically significant.

To examine if MWH services were discussed or introduced to women during ANC contacts, counselling topics were inspected among the 75% (n=2,528) women at endline who said they received advice during ANC visits for their most recent pregnancy. No women reported being informed about MWH services or considering MWH stay as part of their birth preparedness plan. The most common counselling topics centred around care during pregnancy (68% women, n=1,727), the importance of ANC visits (46% women, n=1,172) and the need to plan for safe delivery (42% women, n=1,052). About 35% of women (n=904) were also informed about danger signs during pregnancy and, to a lesser extent during birth and the postpartum period. A similar lack of any focus on MWHs was revealed when topics discussed by HEWs during home visits was inspected, with no apparent differences between trial arms.

A7.2.2 Participant responsiveness

A7.2.2.1. Reasons for MWH use

The most common reasons reported by women at endline for ever having used an MWH included expecting complications at birth, living at a distance from the health facility or complying with a referral to an MWH. A higher proportion of women from the usual care arm stayed at MWHs to enable them to get some rest (Figure A7.2.8).

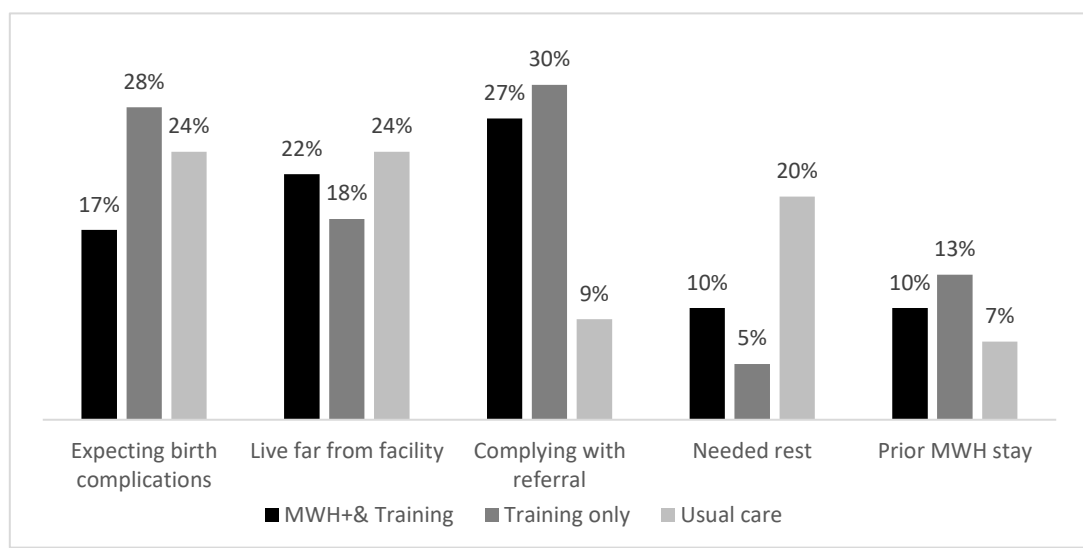


Figure A7.2.8. Most common reasons for MWH use by trial arm (n=171 responses). Multiple responses possible

About half of the responses from women who stayed at an MWH for less than 24 hours prior to giving birth suggested that they were there because complications were expected during birth or were repeat MWH users (Figure A7.2.9). Responses from women who used the MWH for at least a week mainly indicated that in addition to expecting complications during birth, distance played a role in the reason for their stay.

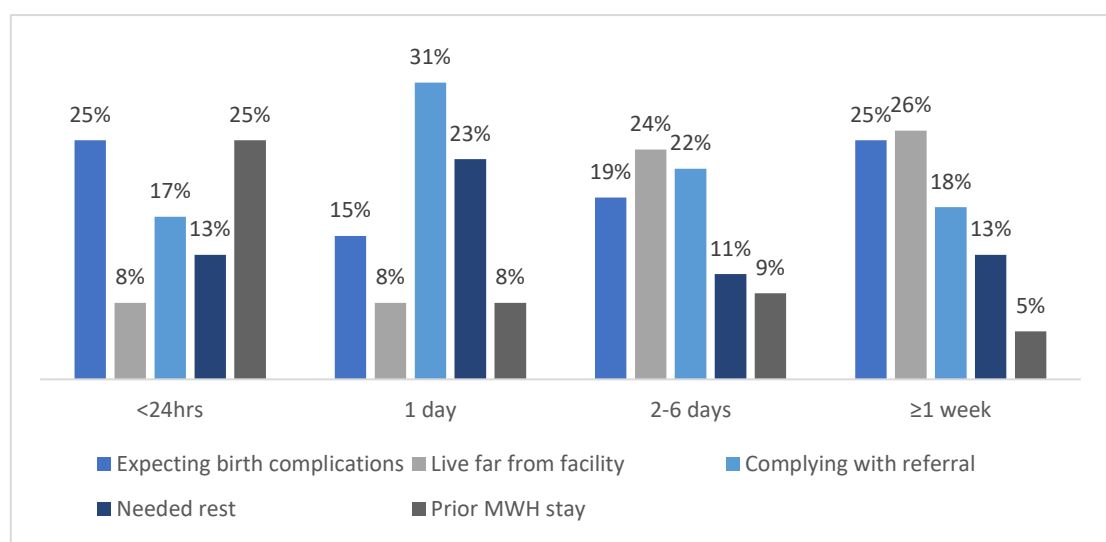


Figure A7.2.9. Reasons for MWH use by duration of MWH stay (n=171 responses). Multiple responses possible.

A7.2.2.2. Integration of MWHs into birth preparedness plans

At endline, 66% (n=2,473) of women reported making some arrangements in anticipation of the birth of their last child, with no significant differences between either trial arms (cluster-adjusted $\chi^2=3.43$, $p=0.180$) or districts (cluster-adjusted $\chi^2=3.77$, $p=0.152$). The most common preparedness components included saving money (80%, n=1,968 women) and organizing transport to a health facility in case of emergency (28%, n=688 women).

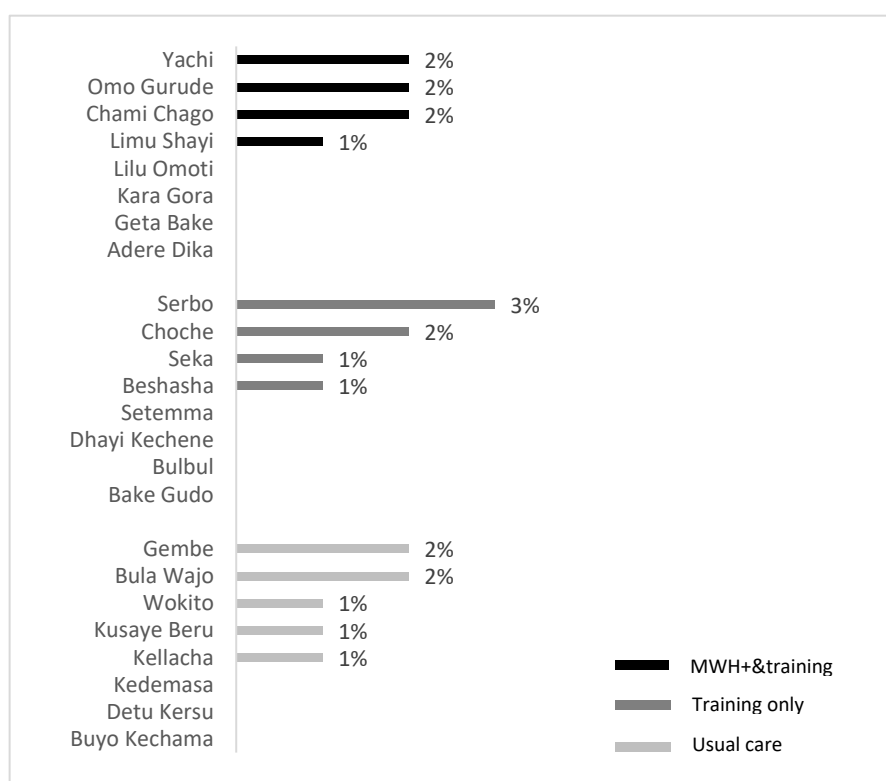


Figure A7.2.10. Percentage of women who reported getting an MWH referral as part of their birth plan by trial arm (n=2,473 women)

About 1% (n=32) of women said they also secured an MWH referral as part of their birth preparations, with no obvious differences between trial arms. Differences between PHCUs was also minimal (Figure A7.2.10) which is not surprising given the low prevalence of the practice.

A7.2.3 Contextual variation, accessibility and needs

A7.2.3.1. MWH use across PHCU clusters

Differences in MWH use during their last pregnancy among women interviewed at endline were significantly different between districts (cluster-adjusted $\chi^2=8.15$, $p<0.05$) and PHCUs ($\chi^2=124.2$, $p<0.001$).

As shown in Figure A7.2.11, MWH use was lowest in Seka Chekorsa district PHCUs with none of the women interviewed at endline from four PHCUs (Seka, Detu Kersu, Buyo Kechama and Bake Gudo) reporting use. Kusaye Beru in Kersa district, which was also in the usual care arm had the highest proportion of MWH users at endline.

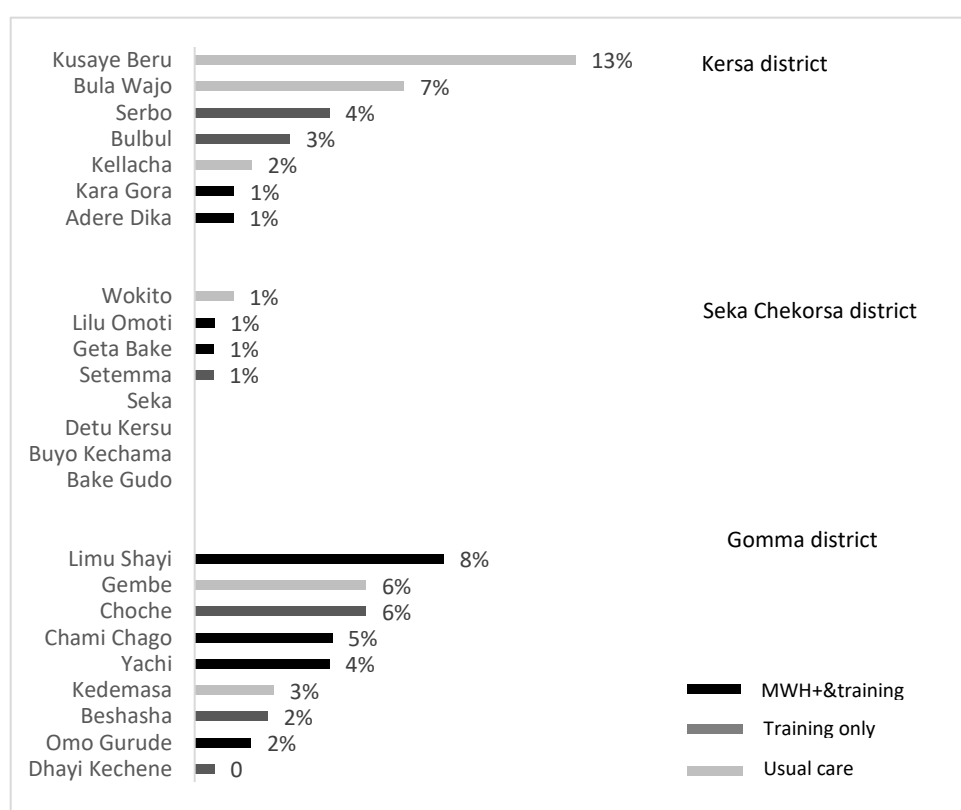


Figure A7.2.11. Percentage of women who used MWHs during their last pregnancy across PHCUs by district and trial arm (n=3,809 women)

A7.2.3.2. Delivery locations across PHCU clusters

Only 1% of women gave birth to their last child en route to a health facility but 39% of women on average delivered their last child at home. While there were no significant differences in home births between trial arms, significant differences existed between both districts (cluster-adjusted $\chi^2=9.63$, $p<0.01$) and PHCUs ($\chi^2=528.0$, $p<0.001$).

As shown in Figure A7.2.12, PHCUs in Seka Chekorsa had high proportions of home births while Gomma PHCUs had relatively lower percentages. However, even within districts there was substantial variation; in Gomma, for instance, Gembe and Choche had less than 15% home births but in Kedemasa 46% of women delivered their last child at home. The percentage of women reporting home births increased steadily as distances between homes and health centres grew (Figure A7.2.13).

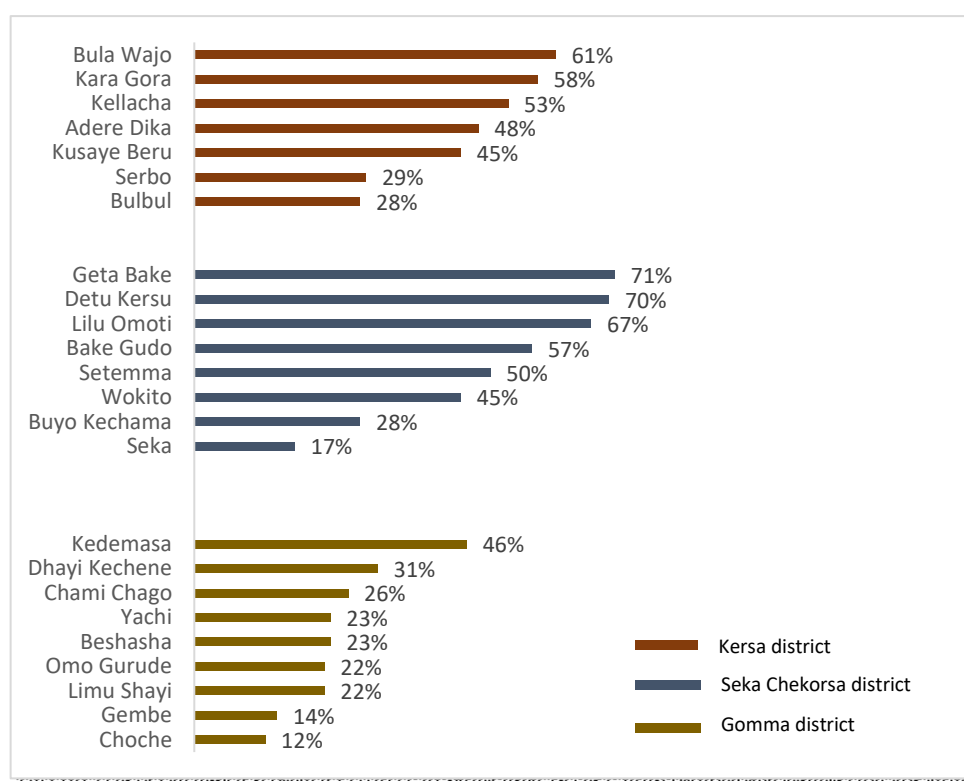


Figure A7.2.12. Percentage of home births across PHCUs by district (n=3,708 women)

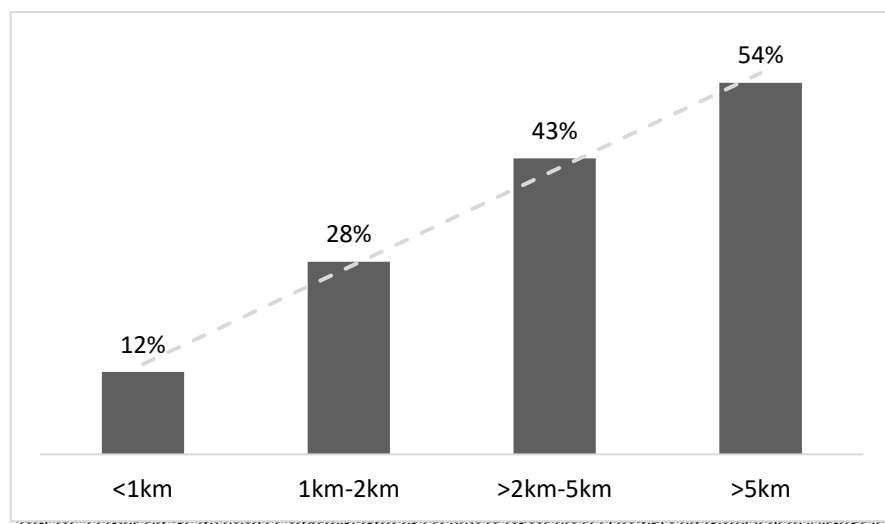


Figure A7.2.13. Percentage of home births by distance from catchment health centre (n=3,770 women)

A7.2.3.3. Distances between homes and health centres across PHCU clusters

Overall, 18% (n=678) of women at endline lived within a kilometre of their catchment health centre, 12% resided between one and two kilometres away but about 70% (n=2,682) were located more than two kilometres away. While there were no statistically significant differences in distances between the trial arm, there significant differences between PHCU clusters.

As shown in Figure A7.2.14, the combined intervention arm generally had fewer PHCUs with a large proportion of households more than five kilometres from the catchment health centre. These differences were also evident when the mean distances between homes and catchment health centres were compared between PHCUs across the three arms. While the average distance was 3.6 kilometres in the combined intervention arm, it was 4.8 kilometres in the usual care arm.

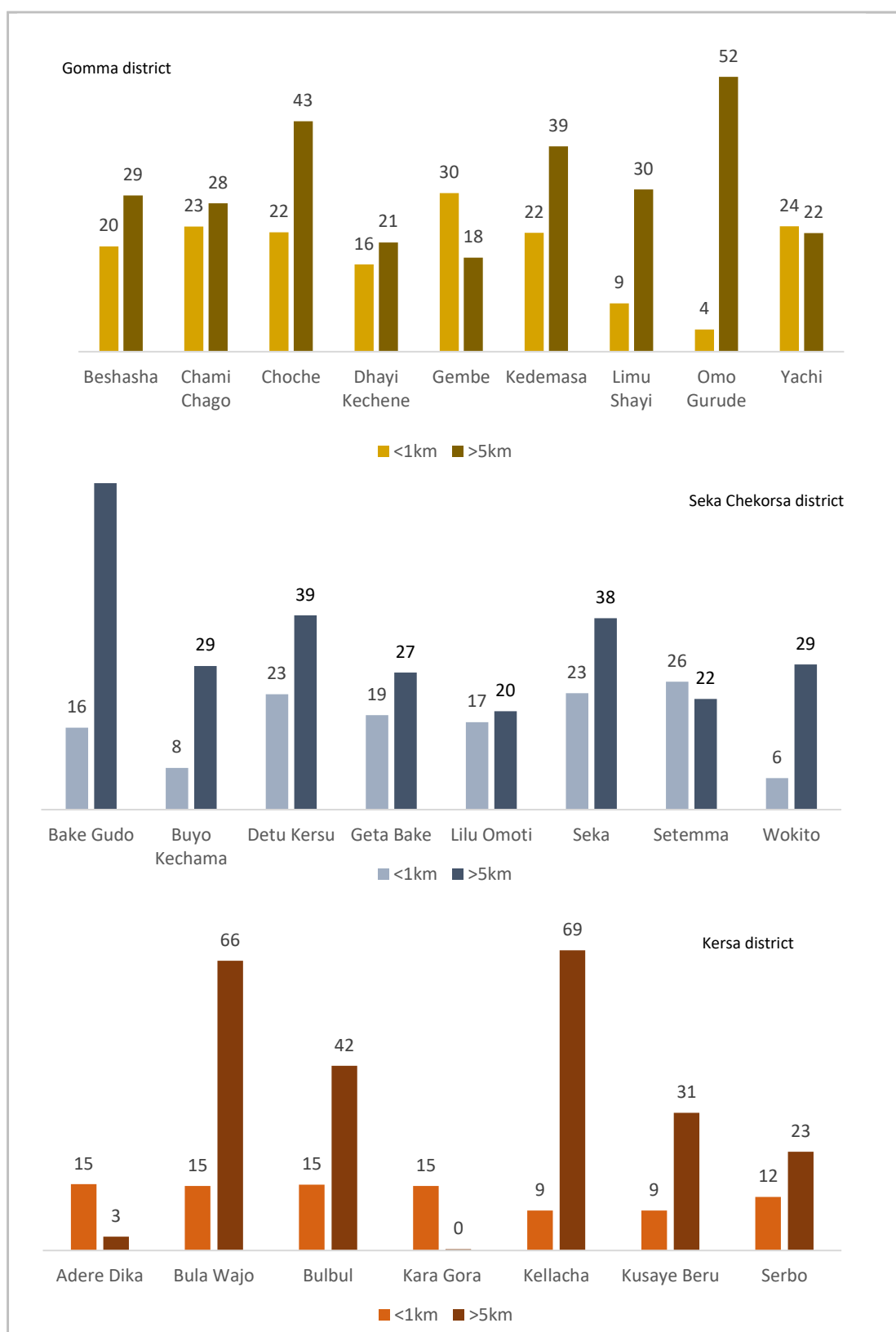


Figure A7.2.14. Comparison of distances between home and health centre across PHCUs by district

A7.2.3.4. Reasons for not giving birth at health facilities across PHCUs clusters

Women who did not give birth to their last child at a health facility provided a range of reasons as to why this was the case. The most common reasons generally fell into four main categories, namely physical access barriers, social barriers, planning issues and health service barriers. About 12% (n=188) of women also explained that they were healthy and, thus, felt no need to use delivery care services. This average was mostly driven by three PHCUs in Kersa and Seka Chekorsa districts which had the highest proportions of women seeing delivery care as unnecessary as they were healthy; the three PHCUs were Bula Wajo (13%), Detu Kersu (11%) and Geta Bake (11%).

PHCUs differed in the extent and combination of barriers faced by women who did not use delivery care services. Physical access barriers included living too far from the facility or not having access to transport. There were no statistically significant differences between trial arms (cluster-adjusted $\chi^2=3.2$, $p=0.519$) in reporting of transport issues as a reason for not using delivery care. However, there were significant differences detected within both districts (cluster-adjusted $\chi^2=13.7$, $p<0.01$) and PHCUs ($\chi^2=106.9$, $p<0.001$). As shown in Figure A7.2.15, transport constraints were cited as a barrier to delivery care use by a larger percentage of women in Gomma district than Kersa district. As an

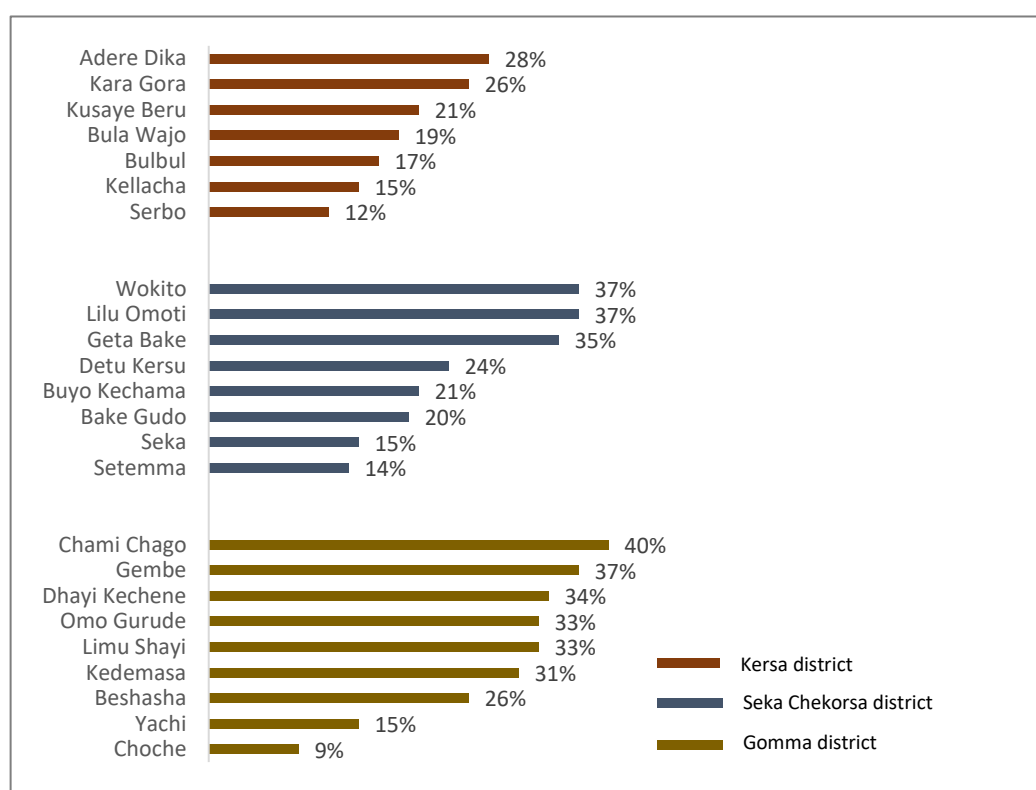


Figure A7.2.15. Percentage of women reporting lack of transport as a barrier to delivery care use across PHCUs by district (n=1,635 women)

illustration of differences between PHCUs within districts, only 9% of women who did not use delivery care attributed it to transport barriers in Choche unlike Chami Chago where 40% of women felt this way.

Similar results were obtained for distance as a barrier with differences between districts (cluster-adjusted $\chi^2=12.3$, $p<0.05$) and PHCUs being statistically significant ($\chi^2=126.2$, $p<0.001$). Variations within PHCUs were slightly different when it came to viewing distance as a barrier to delivery care access. In Gomma district, for instance, 28% of women from Kedemasa felt that living too far from the health centre prevented them from using delivery care (Figure A7.2.16) which was similar to the percentage in this PHCU that felt transport was an issue (31%, Figure A7.2.15). However, whereas 40% of Chami Chago women felt transport was a problem (Figure A7.2.15) only 9% felt distances were too large (Figure A7.2.16).

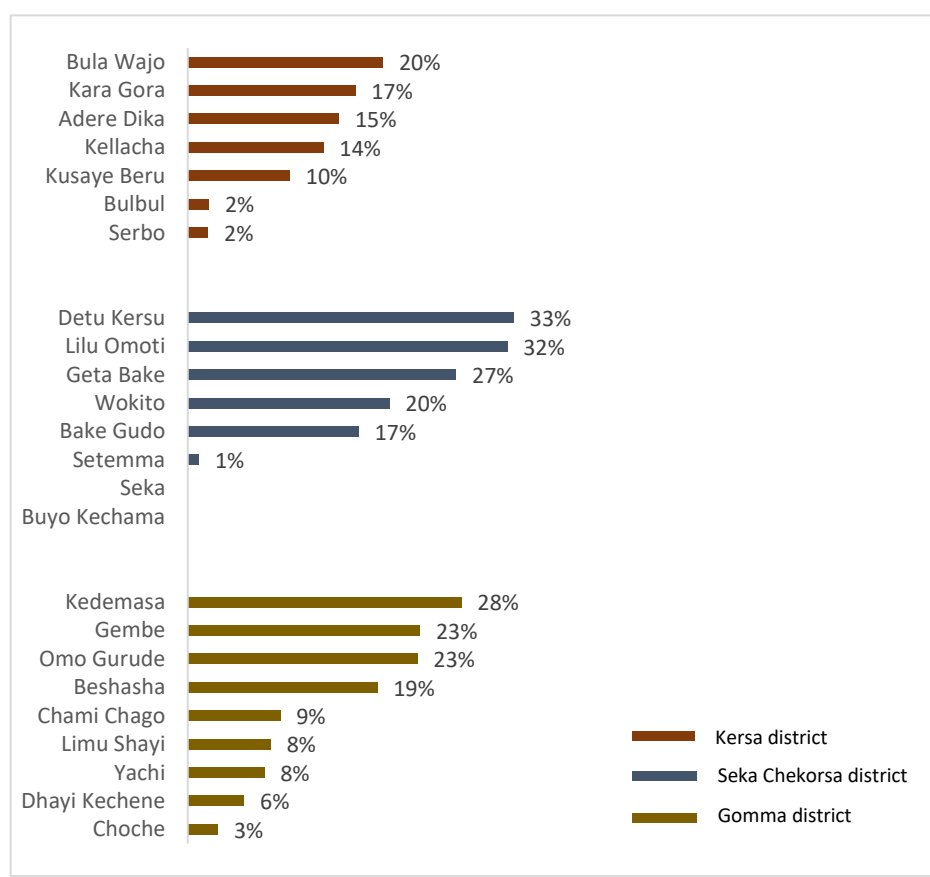


Figure A7.2.16. Percentage of women reporting distance a barrier to delivery care use across PHCUs by district (n=1,635)

Overall, about 20% of women (n=297 responses, 14%) described going into labour as an “emergency” which prevented them from using delivery care services for their last child. This could partially be a reflection of the lack of appropriate birth preparedness planning. This group of women

does not include the 2% of women who explained that they went into labour at night (n=29 responses, 1.3%) or the 1% who said that ambulance delays or unavailability forced them to deliver at home (n=14 responses, 1%). About 10% of other responses which included women not knowing their expected delivery date or not realizing they were in labour until it was too late.

A7.2.3.5. Community and religious leaders as sources of practical support across PHCUs clusters

Overall, the majority of women (85%, n=3,248) interviewed at endline said that they received practical support during their most recent pregnancy; this included assistance with tasks such as household chores, food preparation, child care or cattle herding, etc. There were no significant differences in receiving practical support noted between trial arms (cluster-adjusted $\chi^2=0.69$, $p=0.709$) or districts (cluster-adjusted $\chi^2=1.82$, $p=0.402$); however, significant differences did exist between PHCUs ($\chi^2=60.2$, $p<0.001$). Family members, primarily husbands (67% women) and parents (58% women), were the most common sources of practical support whereas religious groups (4%) were not. Community groups were hardly ever mentioned, but 35% of women did obtain support from friends and neighbours, some of whom may belong to the Development Army.

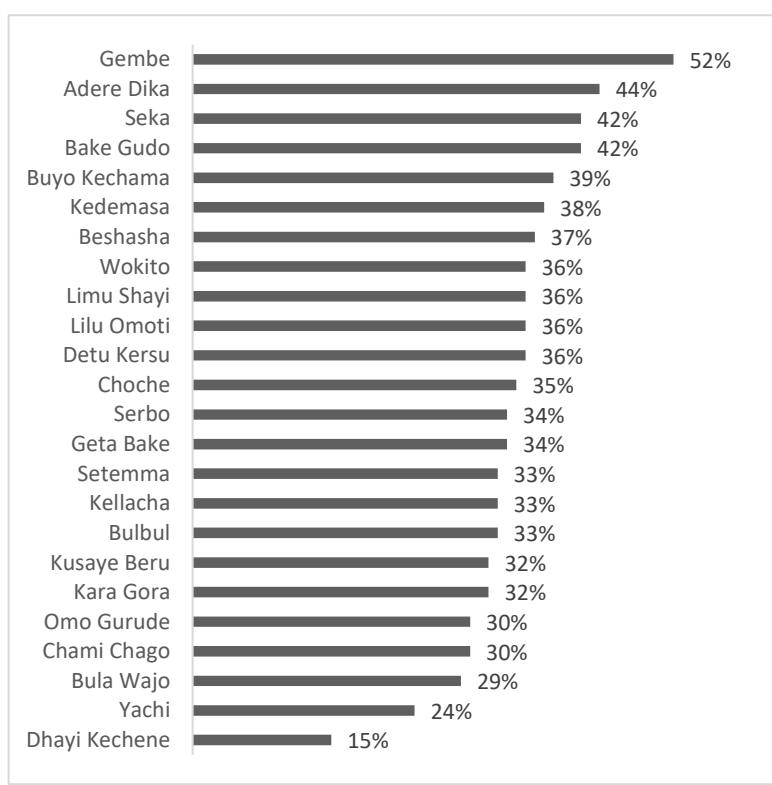


Figure A7.2.17. Percentage of women who received practical support from friends and neighbours across PHCUs (n=3,248 women)

Differences between PHCUs were evident in practical support received from friends and neighbours as shown in Figure A7.2.17. Neighbours and friends as sources of practical support for women ranged from as high as over half of the women in Gembe to as low as only 15% in Dhayi Kechene.

A7.2.3.6. Group membership and program participation across PHCU clusters

About 22% (n=843) of women at endline were members of social or community groups. Though differences were neither significant between trial arms nor districts, PHCUs exhibited statistically differed significantly in group membership ($\chi^2=170.0$, $p<0.001$). The percentage of women who were members of a social or community group varied quite widely between PHCUs and ranged from as low as 11% in Dhayi Kechene to 44% in Gembe (Figure A7.2.18).

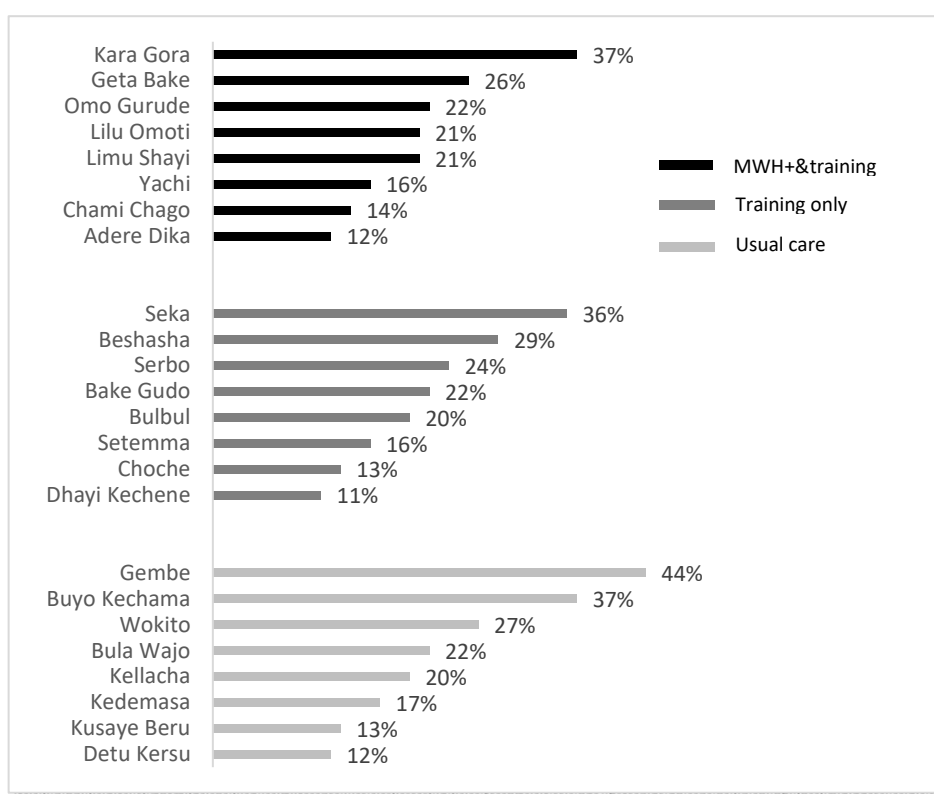


Figure A7.2.18. Percentage of women who were members of social/community groups across PHCUs by trial arm (n=3,809 women)

Most responses indicated that participants were members of women's groups. *Iddirs*³ and savings groups were less common, but there was high variability between PHCUs as is apparent in Figure

³ *Iddirs* are associations that were set up in the early 20th century in Addis Ababa to assist migrants with funeral-related costs. They have since transformed into broader forms of community social insurance, have spread throughout the country and engage in diverse forms of support for contributing members, functioning largely independent of the state. Some *iddirs* are monoethnic while others are more inclusive. Gender-based *iddirs* (ex: specifically for women) have also been recorded.(7)

A7.2.19 which shows the distribution of responses about membership in the three most common social groups after women's groups. Of the 13% of women in Choche PHCU (training only arm) who were members of a social/community group, 34% were part of the WDA.

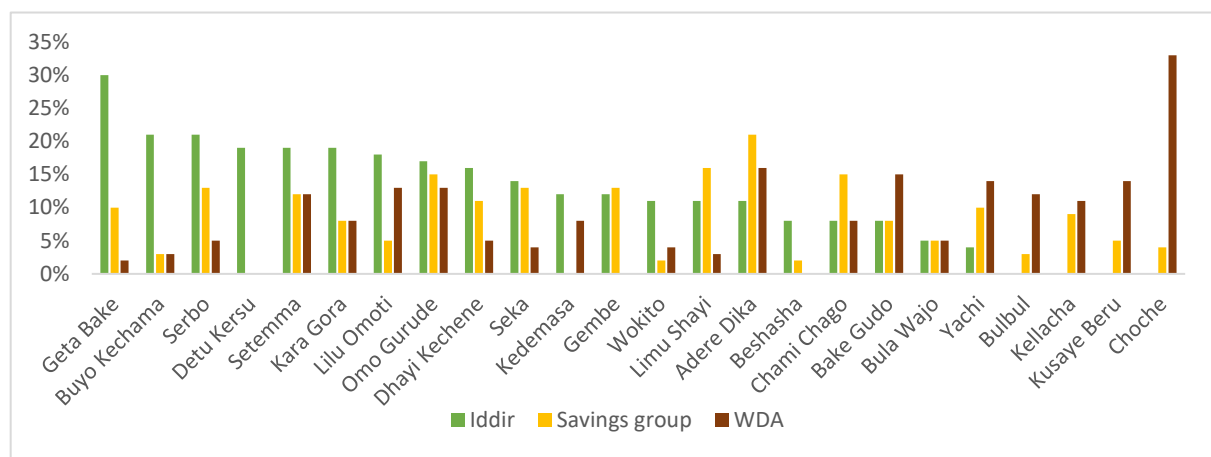


Figure A7.2.19. Membership in *iddir*, savings groups and WDA reported by women across PHCUs (n=964 responses). Multiple responses possible

Other less frequently mentioned groups included youth groups (3% women), farmer's groups (2% women), *kebele* committee (2% women) and teachers association (<1%) (results not shown).

When asked about their participation in programs promoting the use of antenatal, delivery or postnatal care in their area, about 12% of women indicated that they had been exposed to these within the past 12 months.

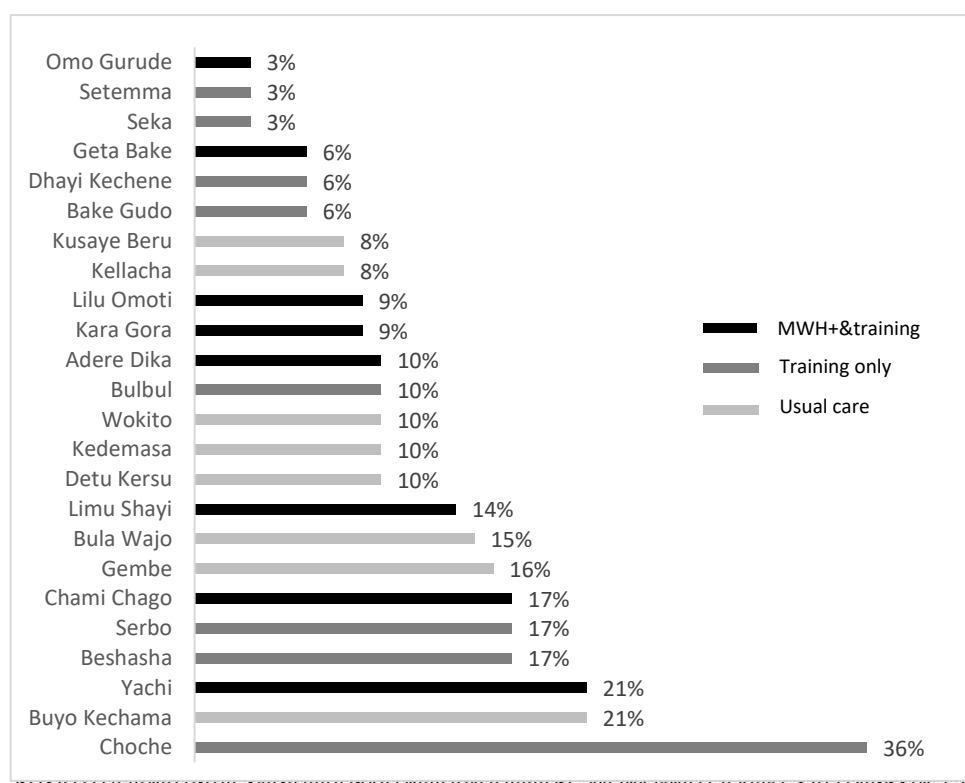


Figure A7.2.20. Percentage of women participating in programs promoting service use across PHCUs by trial arm (n=3,809 women)

There were no differences in participation between trial arms (MWH⁺& training: 11%, training only: 12%, usual care: 12%) or districts (Gomma: 16%, Seka Chekorsa: 8%, Kersa: 11%). However, statistically significant differences were detected between PHCU clusters ($\chi^2=194.6$, $p<0.001$). Participation levels ranged from 3% in Omo Gurude (Gomma district), Setemma and Seka (Seka Chekorsa district) to as high as 36% in Choche (Gomma district) (Figure A7.2.20).

A7.2.3.7. Mobile phone ownership across PHCU clusters

While there were no statistical differences in mobile telephone ownership between trial arms, significant differences were found between PHCUs. As shown in Figure A7.2.21, PHCUs varied markedly between levels of mobile phone ownership, ranging from as low as 13% to as high as 43%. PHCUs located in Gomma district generally had higher proportions of mobile telephone owners.

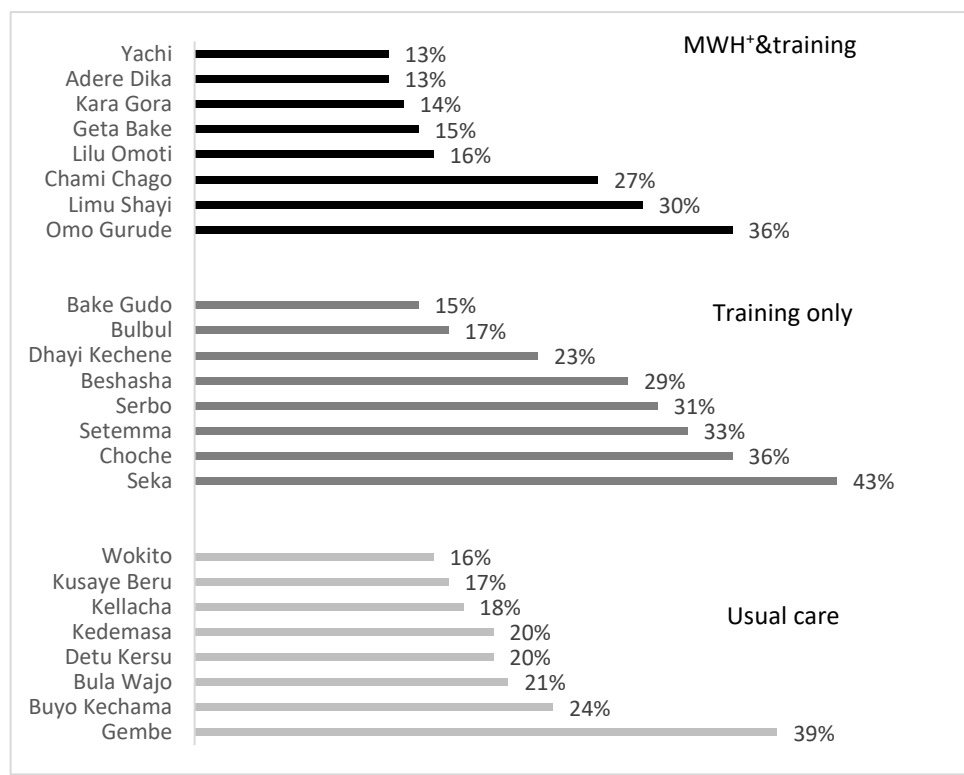


Figure A7.2.21. Percentage of women reporting mobile phone ownership across PHCUs by trial arm (n=3,809 women)

Appendix 7 References

1. Mowbray CT, Holter MC, Teague GB, Bybee D. Fidelity criteria: Development, measurement, and validation. *Am J Eval.* 2003;24(3):315–40.
2. Carroll C, Patterson M, Wood S, Booth A, Rick J, Balain S. A conceptual framework for implementation fidelity. *Implement Sci.* 2007;2(40).
3. Moore G, Audrey S, Barker M, Bond L, Bonell C, Cooper C, et al. Process evaluation in complex public health intervention studies: the need for guidance. *J Epidemiol Community Health.* 2013;0(0).
4. Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *Am J Community Psychol.* 2008;41:327–50.
5. Borrelli B. The assessment, monitoring, and enhancement of treatment fidelity in public health clinical trials. *J Public Heal Dent.* 2011;71(s1):S52–63.
6. Breitenstein SM, Gross D, Garvey CA, Hill C, Fogg L, Resnick B. Implementation fidelity in community-based interventions. *Res Nurs Heal.* 2010;33(2):164–73.
7. Pankhurst A. The Emergence, Evolution and Transformations of iddir Funeral Associations in Urban Ethiopia. *J Ethiop Stud.* 2008;41(1/2 Special Issue (Jun-Dec)):143–85.