Socioeconomic Inequality and HIV in Nigeria: Conclusions from the 2013 Nigerian Demographic and Health Survey

MSc Thesis

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This thesis is dedicated to the individuals who are living with or are at risk of HIV in Nigeria, and to those who support them, particularly under conditions in which access to sexual health information, preventive services, and treatment continues to be hindered by social and economic inequalities.

Socioeconomic Inequality and HIV in Nigeria: Conclusions from the 2013 Nigerian Demographic and Health Survey

RÉSUMÉ / ABSTRACT

[English follows]

Contexte: Alors que le taux de transmission du VIH demeure élevé en Afrique subsaharienne, l'effet de l'inégalité de la richesse, et non seulement l'effet de la richesse absolue, a fait l'objet de recherches récentes comme facteur contribuant à l'épidémie de VIH, mais n'a pas encore été étudié dans le contexte nigérian. Étant donné que les circonstances d'inégalités socioéconomiques peuvent à la fois empêcher des individus d'obtenir des connaissances concernant le VIH, ainsi que de pouvoir traduire ces connaissances en mesures préventives, il est pertinent d'évaluer le niveau de connaissances sur le VIH parmi la population nigériane, de déterminer ses prédicteurs socioéconomiques et d'identifier les groupes les plus à risque d'avoir une faible connaissance du VIH, qui par conséquent sont aussi les groupes potentiels les plus à risque d'avoir une probabilité de transmission élevée de la maladie. Cela permettrait de mieux pouvoir viser des interventions préventives appropriées et efficaces à ces groupes. En raison de la forte prévalence du VIH au Nigéria, ainsi que son hétérogénéité ethnique et socioéconomique, il s'agit d'un contexte à la fois intéressant et pertinent pour l'analyse des déterminants socioéconomiques des connaissances du VIH.

Méthodes: Utilisant les données de l'enquête démographique et santé nigériane, l'article 1 de cette thèse évalue l'inégalité de la richesse comme prédicteur du niveau de connaissances sur le VIH parmi la population nigériane, ainsi que l'effet d'autres facteurs sociodémographiques tels que le sexe, l'alphabétisation et le lieu de résidence rurale ou urbaine sur le niveau de connaissances du VIH. Nous faisons cela par la construction et l'analyse d'un modèle de régression logistique. Dans le deuxième article, une analyse des tendances concernant les connaissances du VIH dans le pays de 2003 à 2013 est réalisée. Les changements dans ces tendances sont représentés graphiquement, stratifiés par divers facteurs sociodémographiques. Des modèles ARIMA ont aussi été ajustés aux données des tendances de 2003 à 2013. Finalement, l'article 3 présente une revue systématique (réalisée dans les bases de données Medline et Embase) et une méta-analyse (réalisée en utilisant R) des interventions pour améliorer les connaissances sur le VIH en Afrique subsaharienne ou parmi la diaspora africaine, synthétisant les études disponibles de l'efficacité de telles interventions pour 1) améliorer le niveau des connaissances sur le VIH, 2) mener à une augmentation de

l’adoption de mesures préventives et de pratiques sexuelles sécuritaires, et 3) réduire l'incidence du VIH. Les méta-analyses présentées sont basées sur des modelés à effets aléatoires.

Résultats: Le modèle de régression logistique a indiqué que les femmes étaient plus de deux fois plus susceptibles que les hommes d'avoir de faibles connaissances concernant le VIH à chaque niveau d'inégalité de la richesse. De plus, malgré que les femmes étaient mieux informées que les hommes en ce qui concerne la transmission du VIH de la mère à l'enfant, elles avaient plus de 1,5 fois plus de chances d'avoir des connaissances insuffisantes sur les mesures de réduction du risque de contracter le VIH. Les personnes ayant un faible niveau d'alphabétisation étaient presque deux fois plus susceptibles que les personnes alphabétisées d'avoir de faibles connaissances sur le VIH. L'appartenance ethnique, l'appartenance religieuse, le statut relationnel et le fait de résider dans les régions rurales constituaient d'autres prédicteurs significatifs du niveau de connaissances sur le VIH. L'analyse des tendances a indiqué une augmentation globale des connaissances sur le VIH entre 2003 et 2013, mais malheureusement une diminution des connaissances sur la transmission du virus de la mère à l'enfant. En outre, les disparités entre les États du pays dans les niveaux de connaissances concernant la réduction du risque de contracter le VIH ont augmenté au fil du temps. La méta-analyse des interventions éducatives sur le VIH a demontré des effets significatifs sur l’amélioration de la connaissance des modes de transmission du VIH et de l’utlilisation des condoms, mais pas sur l’incidence du VIH.

Conclusion: Les connaissances sur le VIH de cet échantillon sont généralement faibles chez les femmes, les personnes peu alphabétisées, les pauvres, les individus sans emploi, les habitants de zones rurales, les individus ayant des croyances religieuses traditionnelles et ceux vivant dans les États ayant les ratios d'inégalité de la richesse les plus élevés. La synthèse des études sur l’efficacité d’interventions éducatives sur le VIH dans l’article 3 indique que de telles interventions sont efficaces à améliorer les connaissances sur le VIH ainsi qu’à augmenter l’utilisation des condoms, et devraient alors être considérées pour la diffusion parmi des groupes spécifiques les plus à risque de contracter le VIH, comme ceux identifiés dans les articles 1 et 2, à fin de réduire sa transmission.

Background: As high HIV transmission rates persist in Sub-Saharan Africa, the effect of wealth inequality rather than solely absolute wealth as a potential driver of the HIV epidemic has been given increased attention in recent research, but has not yet been investigated in the Nigerian setting. As, particularly in contexts of socioeconomic inequality, individuals may face barriers to both obtaining health-related knowledge and translating this knowledge into actual engagement in preventive measures, it is relevant to assess the level of HIV-related knowledge in the Nigerian population. Furthermore, it is of interest to investigate its socioeconomic predictors, and to identify risk-groups for low HIV-related knowledge, which consequentially are also potential risk groups for high HIV transmission. This will ultimately facilitate the targeting and implementation of more appropriate and effective preventive interventions among these groups. Due to the country's high HIV prevalence and its ethnic and socioeconomic heterogeneity, it is both an interesting and highly relevant setting in which to analyse the socioeconomic determinants of HIV-related knowledge.

Methods: Utilizing data from the Nigerian Demographic and Health Survey, Paper 1 of this thesis investigates wealth inequality as a predictor of low HIV-related knowledge in the Nigerian population through logistic regression modeling. The effects of other sociodemographic factors such as sex, literacy and rural or urban residence on HIV-related knowledge are also explored. In paper 2, a trend analysis is conducted of HIV-related knowledge in the country from 2003 to 2013, with changes in these trends represented graphically, stratified by various sociodemographic factors. ARIMA models were fit to the 2003-2013 trend data. Finally, Paper 3 presents a systematic review (using the Medline and Embase databases) and meta-analysis (conducted in R) of HIV-related knowledge interventions in Sub-Saharan Africa or among the African Diaspora, synthesising the available evidence for the efficacy of such interventions in 1) improving HIV-related knowledge, 2) resulting in increased engagement in preventive measures and safe sexual practices, and 3) reducing HIV incidence. Random-effects models were used for the meta-analyses.

Results: The logistic regression model indicated that females were more than twice as likely as males to have low HIV-related knowledge in each wealth inequality category. In addition, females were more likely to have correct knowledge of mother-to-child transmission than males, but were over 1.5 times more likely to have poor knowledge of HIV risk reduction measures. Individuals with lower literacy levels were almost twice as likely as literate

respondents to have low HIV-related knowledge. Ethnicity, religious affiliation, relationship status, and residing in rural areas were additional significant predictors of HIV-related knowledge. The trend analysis indicated an overall increase in HIV-related knowledge between 2003 and 2013, but a decrease in knowledge of mother-to-child-transmission. In addition, State-level disparities in knowledge regarding HIV risk reduction increased over time. The meta-analysis of HIV education interventions demonstrated significantly higher odds of correct knowledge of transmission routes as well as condom use, but insignificantly lower odds of HIV incidence.

Conclusions: HIV-related knowledge in this sample is generally low among females, those with low literacy levels, the poor, the unemployed, those residing in rural areas, those with traditional religious beliefs, and those living in states with the highest wealth inequality ratios. The meta-analysis of HIV-related knowledge interventions in Paper 3 indicates that such interventions are generally effective at improving not only HIV-related knowledge but also increasing condom use, and should thus be targeted at the risk groups identified in Papers 1 and 2, in order to work towards the reduction of HIV transmission.

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ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
ANOVA	Analysis of Variance
ARIMA	Autoregressive Integrated Moving Average
ART	Anti-Retroviral Therapy
DHS	Demographic and Health Survey
EA	Enumeration Area
HIV	Human Immunodeficiency Virus
LGA	Local Government Area
MAPE	Mean Absolute Percentage Error
MTCT	Mother-to-Child Transmission
NACA	National Agency for the Control of AIDS
NDHS	Nigerian Demographic and Health Survey
NSP	National Strategic Plan to Combat HIV/AIDS
SD	Standard Deviation
UNAIDS	Joint United Nations Program on HIV/AIDS
USAID	United States Agency for International Development
WHO	World Health Organization

Geopolitical zones of Nigeria:

NE	North East	NC	North Central	NW	North West
SE	South East	SS	South South	SW	South West

CHAPTER ONE: INTRODUCTION

1.1 Problem Statement

Although numerous studies have investigated the association between poverty and Human Immunodeficiency Virus (HIV) transmission, more recent studies indicate that wealth inequality, and not poverty itself, drives HIV transmission in Sub-Saharan Africa. (1-3) With 3.5 million people living with HIV in Nigeria as of 2015, the country has the second highest number of HIV cases in the world (4) and alone constitutes 9% of the global prevalence of HIV (5), making the country a particularly relevant setting for continued studies into the social and economic correlates of HIV transmission. Unfortunately however, the existing body of studies on the role of wealth inequality in shaping HIV epidemics thus far does not include Nigeria. (2, 3) Especially considering Nigeria's high inter-regional ethnic, social and economic heterogeneity, (6, 7) an analysis of how state-level wealth inequality influences HIV-related attitudes and knowledge, and consequently drive the epidemic, is highly relevant. The current lack thereof hinders effective community-specific, targeted interventions and programs to reduce HIV transmission and improve HIV-associated health outcomes.

1.2 Background

1.2.1 The Molecular Biology, Transmission, Prevention, and Treatment of HIV

HIV is a retrovirus, capable of using host cell mechanisms for the transcription of viral DNA into RNA, the subsequent production of viral proteins, and ultimately, new virions. Infection with HIV leads to progressive depletion of $CD4^+$ T cells, and thus the weakening of the host immune system, in turn subjecting the host to increased susceptibility to infections (and other complications, such as impaired renal and hepatic function). (8) Continued loss of $CD4^+$ T cells leads to progression to Acquired Immune Deficiency Syndrome (AIDS) (in approximately 10 years from initial infection), characterised by the emergence of an AIDS-defining illness (including certain cancers such as lymphoma, or infectious diseases such as tuberculosis or recurrent pneumonia) or a $CD4^+$ T cell count <200 cells/µl, (9) although this can be prevented through the initiation of anti-retroviral therapy (ART) and the establishment of viral suppression. (8)

HIV is primarily transmitted through sexual intercourse, although other transmission routes include through contact with infected blood (such as during the sharing of needles for

injection drug use, or receiving blood transfusions), or transmission from mother to child during pregnancy, delivery, or breastfeeding. (10) The sexual transmission of HIV is preventable through correct and consistent condom use, as well as through the use of ARTs as pre-exposure prophylaxis for HIV-negative individuals. The prevention of mother-to-child transmission is also achieved through the use of ARTs in HIV-infected mothers, as well as their prophylactic use in the infant. (8)

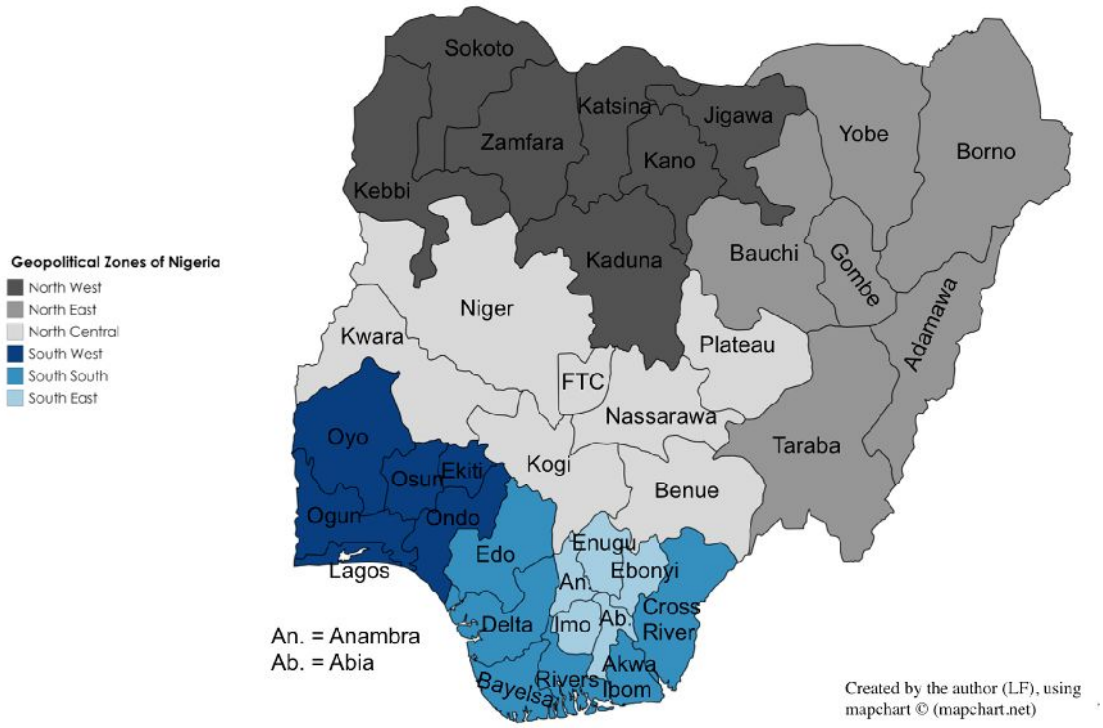
Despite the availability of preventive measures however, gender inequities and prevalent social norms regarding sexual practices continue to present barriers to preventive behaviour such as condom use. This suggests the need, as part of ongoing prevention efforts, to also address the social determinants that lead to low awareness of HIV, underestimation of personal risk, or disempowerment regarding sexual decision-making and preventive healthcare seeking. (11) Lastly, although there is no cure for HIV, long-term viral suppression can be achieved through adherence to anti-retroviral treatment, (8) however, global ART coverage remains to be improved, with only 19.5 million of the 36.7 million people living with HIV/AIDS globally as of 2016 being on ART. (12)

1.2.2 The Epidemiology of HIV in Nigeria

As Nigeria is both the most populous country in Africa (6) as well as the country with the second highest number of people living with HIV in the world, (5) studies into the epidemiology of HIV in the Nigerian context continue to be pertinent. In 2014, the country experienced an incidence of 220,000 new HIV cases, (7) and 180,000 deaths were attributed to HIV in Nigeria in 2015. (4)

Although the overall prevalence of HIV in Nigeria is estimated at 3.4%, there are considerable differences in prevalence at the regional level, ranging from 1.8% in Nigeria's South East Zone (see **Figure 1.1**) to as high as 5.5% in the South South Zone. (13) Wide disparities in HIV prevalence are also seen at the state level, with the states of Karuna (NW) Nasarawa (NC), Taraba (NE) and Rivers (SS) having a prevalence > 8.0%, (with the highest prevalence of 15.2% occurring in Rivers) whilst the lowest-prevalence state of Ekiti (SW) experienced a comparatively low prevalence of 0.2%. (14) Specific risk factors for HIV in the Nigerian context are described in **Section 3.1.**

Figure 1.1: Map of Geopolitical Zones of Nigeria



1.2.3 The Nigerian Epidemic in the Global Context: Progress Towards 90-90-90

Following the expiry of the millennium development goals in 2015, the Joint United Nations Program on HIV/AIDS (UNAIDS) current global targets for HIV/AIDS elimination, referred to as the 90-90-90 targets, articulate the following goals to be attained by 2020: 90% of all individuals living with HIV will know their status, 90% of those diagnosed will be on ART, and in turn, 90% of those on ART will be virally supressed. (15) Given that only about half (53%) of all individuals living with HIV globally were on ART in 2016, (16) attaining the 90-90-90 targets remains a challenge.

Considering where Nigeria is situated with regards to these targets, according to 2017 estimates, 34% of individuals living with HIV in Nigeria were diagnosed, 88% of those diagnosed were on ART, and 81% of those on ART achieved viral suppression. (17) Importantly however, when considering the total number of individuals living with HIV as the denominator (rather than those diagnosed or those on ART, respectively), in 2016, only 30% of all Nigerians living with HIV were on ART, and only 24% were virally supressed. (17) This indicates that, for Nigeria in particular, improvements in the initial target of

diagnosis and status awareness are critical to increasing overall uptake of treatment and achieving the subsequent targets of sustained ART uptake and viral suppression.

Lastly, beyond 90-90-90, UNAIDS has identified further AIDS elimination targets to be reached by 2030, outlined in the 2016 United Nations political Declaration on Ending AIDS. Rather than focusing on diagnosis, ART initiation, and viral suppression, these expanded elimination goals also pertain to HIV prevention and addressing the social inequities that increase vulnerability to HIV. In particular, one target calls for ensuring that 90% of young adults have access to the skills and knowledge to prevent HIV transmission. (18) This underlines the importance of improving HIV-related knowledge in the overall global agenda to stem the spread of HIV, and the relevance of examining the social correlates of HIV-related knowledge in Nigeria.

1.2.4 Nigeria's National HIV Awareness Campaign

In working towards the millennium development goal (MDG6) of halting and beginning to reverse the spread of HIV/AIDS by 2015, Nigeria launched its National Strategic Plan (NSP) (running from 2010 to 2015) to combat HIV/AIDS. This program focuses on prevention, aiming to reduce the transmission of the disease through the modification of behavioural practices and improving public HIV-related knowledge. (13) Importantly however, despite including the support of research activities and the reduction of gender inequities in its mandate, Nigeria's National Agency for the Control of AIDS (NACA) reports that evidence-based programing and gender-based approaches in the strategy remain to be improved. (13) This could in part be achieved through a greater understanding of how socioeconomic and gender inequalities influence HIV-related knowledge, which the current study aims to gain.

1.2.5 ART Coverage and Factors Influencing Access to ART

Since the beginning of its national program for ART distribution in 2002, (19) Nigeria has made significant progress in terms of the distribution of antiretroviral therapy (ART) for the treatment of HIV/AIDS, with a number of governmental programs as well as non-governmental organisations such as the President's Emergency Plan for AIDS Relief (PEPFAR) contributing to improving ART coverage in the country. (20) According to 2014 estimates, 44.9% of Nigerians with CD4 counts below 350 cells/mm^3 (the threshold at which Nigerian national guidelines recommend ART initiation (21)) received ART, which is a considerable improvement in coverage compared to previous years, (13) although, as

mentioned above, only under one third of all individuals living with HIV in Nigeria were on ART as of 2017. (17) In addition, despite efforts towards increased ART coverage, access alone does not guarantee improved health outcomes, as barriers to long-term adherence to treatment must also be addressed.

As a review of factors influencing non-adherence to ART in Nigeria identifies both financial limitations and stigma as two of the most common adherence barriers, (19) HIV-related attitudes and wealth may significantly influence successful completion of ART and consequently HIV-associated health outcomes. Furthermore, poverty itself may not be as significant an indicator of adherence as socioeconomic inequality, as previous studies indicate high levels of adherence to ART in settings of generalized poverty and marginalization, (19, 22, 23) again underlining that the role of various parameters of inequality in sustaining the Nigerian HIV epidemic should be further explored.

1.2.6 Socioeconomic Inequality and HIV

It is well established that health indicators often follow a social gradient, with the poor being both more likely to contract disease and less likely to experience positive subsequent health outcomes. (24) Therefore, many studies of HIV epidemiology have focused on poverty as a risk factor for HIV infection. However, in recent years, studies have reported that, particularly in Sub-Saharan Africa, socioeconomic inequality is a stronger driver of HIV transmission than absolute measures of poverty or wealth. (1-3, 25, 26) Despite Nigeria's high overall HIV prevalence, its wide disparities in state-level HIV prevalence, and the highly socioeconomically heterogeneous nature of its states, the association of socioeconomic inequalities with HIV-related knowledge in Nigeria has not yet been investigated. (2, 3) This study therefore aims to fill this knowledge gap, in order to provide a more profound understanding in particular of how state-level wealth inequality, as well as other sociodemographic factors such as sex, age, and literacy, influence disparities in HIV-related knowledge, thereby providing an evidence base for the targeting of educational interventions among risk groups for low HIV-related knowledge.

For the purpose of this thesis, socioeconomic inequality encompasses both social and economic disparities among and within populations. Social inequalities include inequalities due to disparate literacy levels, educational attainment, sex, or employment status and wealth inequality is defined as the difference in relative wealth (as opposed to absolute wealth)

between states. The wealth ratio is a measure of wealth inequality used in prior analyses of wealth inequality in sub-Saharan African countries, and is the ratio of mean household wealth among households in the upper 20th wealth quintile to that of those in the lower 20th wealth quintile, (3) and is used in the analyses that follow. Further details regarding how other socio-demographic parameters are measured are discussed in **Section 4** (Methods).

1.3 Research Questions

1. Does state-level wealth inequality influence HIV-related knowledge in Nigeria? What other socioeconomic and demographic factors influence HIV-related knowledge and attitudes in the country?
2. Has HIV-related knowledge increased in Nigeria between 2003 and 2013?
3. What types of interventions are effective in a) increasing HIV-related knowledge among the Sub-Saharan African population or the African diaspora, b) leading to increased preventive behaviours and safe sexual practices in this population, and c) ultimately reducing HIV incidence?

1.4 Objectives

1. To describe and quantify the associations between wealth inequality and HIV-related knowledge in Nigeria, and to investigate other correlates of HIV-related knowledge.
2. To analyse the trend in HIV-related knowledge levels in Nigeria between 2003 and 2013.
3. To meta-analyse the evidence for the effectiveness of HIV-related knowledge interventions implemented in Sub-Saharan Africa or among the African diaspora in a) increasing HIV-related knowledge, b) increasing engagement in preventive behaviours and safe sexual practices, and c) reducing HIV incidence.

1.5 Rationale for the Current Study

Considering Nigeria's large population and high national HIV prevalence, (6) it is relevant to more precisely understand the dynamics of the Nigerian HIV epidemic. While earlier studies of the socioeconomic determinants of HIV infection in Sub-Saharan Africa have mostly limited their analyses to the association between absolute wealth and HIV infection, (1) very few studies have considered wealth *inequality* as a driver of HIV transmission in Sub-Saharan Africa. (2, 3, 25, 26) Moreover, of these studies, none have investigated the associations between wealth inequality and HIV in Nigeria specifically. Given the notable state-level variations in HIV prevalence, (14) and the socioeconomic and cultural

heterogeneity between and within regions of Nigeria, which result in disparities in HIV-related knowledge and attitudes, (7) determining the association of wealth inequality and other socio-demographic factors with HIV-related knowledge provides insight into how inequalities contribute to driving the epidemic in the country, thus filling an important knowledge gap. Ultimately, therefore, this study will contribute to a more comprehensive and precise understanding of the socioeconomic determinants of the Nigerian HIV epidemic, which in turn will inform the design and implementation of evidence-based and population-specific preventive interventions and policies that aim to improve HIV-related awareness, facilitate access to care for marginalized groups, and improve health outcomes across the social gradient.

1.6 Theoretical Framework

Prior to the examination of HIV-related knowledge in Nigeria, a theoretical framework is presented, within which to examine disparities in access to HIV-related knowledge and prevention resources across socio-demographic strata, particularly under circumstances of wealth inequality. The framework contains elements of both the biosocial and the health-belief model. Firstly, the health-belief model,(27) which has served as the conceptual basis of prior studies in the area of health-related knowledge and HIV,(28) argues that an individual's knowledge regarding a disease influences their perception of their risk of contracting it, and in turn their propensity to take preventive measures.(27) Secondly, as underlined by the biosocial perspective and proponents of social medicine, socioeconomic status determines an individual's ability to access health resources, and the socioeconomically marginalized therefore face structural barriers to accessing these resources, and are consequently at disproportionately high risk of suffering adverse health outcomes.(24, 29, 30)

Combining elements from the two models, we argue here that socio-demographic factors influence not only an individual's access to health information – in this case, to HIV-related knowledge – but also, and importantly, an individual's ability to ultimately transform this information into preventive action in order to actually secure better health outcomes. In addition, we underline that these socio-demographic factors do not necessarily operate in isolation, but rather that the confluence of multiple parameters of socioeconomic marginalization may together determine an individual's risk of low HIV-related knowledge, as well as their ability to use this knowledge to access preventive health resources. For example, focusing on the relationship between sex and wealth inequality in the context of

HIV risk, prior studies have noted that patterns of HIV risk among females compared to males differ across other demographic or socioeconomic parameters.(31)

Considering the potential relationship between wealth inequality, gender, and HIV-related knowledge in Nigeria, this suggests that, being subject to the effects of both gender inequities and wealth inequality, women living in poverty may, firstly, have significantly reduced access to HIV education, thus lowering their HIV risk perception and their propensity to adopt preventive measures. Secondly, given that under circumstances of wealth inequality, women may be driven to engage in transactional sex,(32, 33) our model underlines that their marginalization as a result of both their gender and their poverty creates a scenario in which they are less likely to possess the knowledge to identify their risk of infection, the empowerment to put this knowledge into practice (i.e. to negotiate preventive measures with their partner, such as condom use), and the means to actually access the required health resources (condoms, HIV testing, HIV information). **Figure 4.1 (Chapter 4),** provides a diagrammatic representation of the outlined theoretical framework.

CHAPTER TWO: LITERATURE REVIEW

This literature review was conducted using the Medline and Embase databases on the OVID platform (OVID Technologies, NY), from which full-text articles were then accessed via the University of Ottawa Library, and imported into the citation manager Endnote Basic (Thomson Reuters).

2.1 Risk Groups and Risk Factors for HIV Infection in Nigeria

In Nigeria, married or cohabiting couples currently account for the majority of HIV transmission, being responsible for 42% of new infections. (13) This is suspected to be due to the fact that condom use is low among groups that perceive themselves to be at low risk for HIV infection. (13) High risk groups that also significantly shape the Nigerian HIV epidemic include intravenous drug users (IDUs), men who have sex with men (MSM) and female sex workers, to whom approximately 23% of all new HIV infections are attributed, although, in combination, these groups constitute only 1% of Nigeria's total population. (13) Furthermore, gender is a relevant risk factor for HIV in the country, with HIV prevalence generally being higher among females when controlling for other factors. (7, 13) The prevalence of HIV among female IDUs for example is higher than among their male counterparts, with 2015 prevalence levels of 14 and 3%, respectively. (34)

Lastly, although 170,000 of the 220,000 new cases of HIV in 2014 occurred among people over 15 years of age, (7) children represent an important population subgroup in the Nigerian epidemic, considering that the country had the highest incidence of HIV among children of any country in the world as of 2015. (34) On a related note, mother-to-child transmission remains a significant source of new HIV cases in Nigeria, (13) with an approximate 27.3% of pregnant HIV-positive women in 2014 passing their infection on to their child. (13)

2.2 Sociocultural Factors and Socioeconomic Inequality Influencing Sexual Practices, HIV-related Knowledge and Attitudes in Nigeria

In a setting as culturally heterogeneous as Nigeria, (7, 35) it is highly relevant to consider how sociocultural factors influence safe sexual practices, HIV-related knowledge and attitudes, and consequently affect the likelihood of HIV transmission, health-seeking behaviour and health outcomes. (7) With regards to HIV-related attitudes, a study using data from the 2013 NDHS reported that about 50% of Nigerians (between the ages of 15 and 49)

stigmatize people with HIV in one way or another, such as feeling that people with the disease should be ashamed of themselves, or not wanting to buy products from someone with HIV. (36) Previous studies in Nigeria cite the association of HIV with socially frowned-upon activities such as promiscuity or commercial sex work as a common reason for the stigmatization of people with the disease, as well as the fact that its modes of transmission are often poorly understood, leading to unfounded fear of and discrimination against HIV positive individuals. (37) Importantly, a review of studies on HIV-associated stigma in Nigeria underlines that the extent of stigmatization of the disease varies along geographic and ethnic divisions, with the Yoruba ethnic group in the West of the country having more positive attitudes towards people with HIV/AIDS than the Igbo in Eastern Nigeria. (38)

Apart from cultural and ethnic differences, gender and socioeconomic or demographic inequalities may also drive HIV-related practices and attitudes, with other studies in Sub-Saharan African countries reporting low relative wealth and high gender-based violence being associated with high HIV risk. (39, 40) In Western Africa in general, women often have limited agency to negotiate safe sexual practices with their partners, and if identified as HIV positive, face discrimination and stigmatization, which in turn limits both their willingness and their actual ability to seek treatment or inform partners of their status. (37) In Nigeria in particular, extramarital sex, women's disempowerment, and cultural beliefs regarding contraceptive use are important social correlates of HIV infection. (35, 37) Interestingly, extramarital sex has been shown to be associated with both economic and gender inequality, as women are driven by these circumstances of converging inequalities to engage in transactional sex, (32) or to engage in unprotected sex with other partners when experiencing difficulties conceiving with their husbands, (33) highlighting the importance of investigating the social and economic determinants of HIV-related attitudes in Nigeria through the lens of inequality.

Furthermore, investigating differences not only in HIV-related attitudes but HIV-related knowledge is relevant, as low HIV-related knowledge and consequently low risk-perception (and by extension, unsafe sex practices) is considered an important contributory factor to the spread of HIV in Nigeria. Detailed studies on how this knowledge differs among socioeconomic and cultural fault lines in the country however are lacking. (13) To this end, the current study aims to investigate how HIV-related knowledge and attitudes (as precursors to HIV-related practices) are influenced by socioeconomic inequality, gender inequality, rural

compared to urban residence, and ethnicity, and consequently how these disparities shape the Nigerian HIV epidemic.

2.3 Socioeconomic Inequality and HIV Transmission in Sub-Saharan Africa

Although many past studies, particularly in Sub-Saharan Africa, have focused on poverty as a driver of HIV infection, (1) the idea that wealth inequality rather than poverty itself is what perpetuates HIV transmission and adverse HIV-associated health outcomes has only been explored more recently. (2, 3, 26) In fact, in some countries, HIV transmission is more frequent among the wealthy, due to wealth-associated factors such as increased travel and higher social mobility (and by extension perhaps higher numbers of sexual partners) (1, 2). This is supported in the case of Sub-Saharan Africa, in which higher-income countries such as South Africa have a higher HIV prevalence. (1) Therefore, although the poor may be more likely to experience adverse health outcomes as a result of HIV infection, they are not necessarily more likely than wealthier people to initially contract it. In contrast, areas with highly unequal distributions of wealth often experience high HIV prevalence. (1, 2) This recognition has underlined the need to examine how wealth inequality (and inequalities in other socioeconomic factors) rather than poverty or wealth in itself, drive the transmission of HIV and determine HIV-related health outcomes.

In a study of within-country economic inequality as a driver of HIV infection in sixteen Sub-Saharan African countries, results indicated that individuals residing in regions of high income inequality were more likely to contract HIV (OR=2.36, $p < 0.01$), even after controlling for wealth at the individual level. Moreover, interestingly, the effect of individual wealth on the likelihood of HIV infection depended on regional wealth inequality such that high individual wealth in an overall poor region was associated with increased likelihood of infection, whilst in generally rich areas, infection was more likely among those with low individual wealth. (2) A further study including six countries in Sub-Saharan Africa, focusing on community-level inequality, corroborated the finding that economic inequality (as measured via the Gini coefficient (a measure of the inequality in a distribution), and the wealth ratio, as outlined above) is associated with a higher risk of HIV infection. (3)

Importantly, economic inequality may not only influence the likelihood of HIV infection itself, but also the likelihood of further downstream HIV-related health factors, such as adherence to ART, as several studies conducted among homogenously poor populations (as

opposed to populations with high economic inequality) report relatively high levels of adherence to ART. (19, 22, 23)

Considering specific Sub-Saharan African countries, a study on HIV among women in Malawi found community as well as district-level economic inequality to be associated with a higher likelihood of HIV infection, whilst individual levels of wealth were not. (26) Similar results were reported in a study on economic inequality and HIV in South Africa, where increased municipal economic inequality was found to be associated with a higher likelihood of contracting HIV. (25) These results underscore the relevance of considering the dynamics of socioeconomic inequality and the mechanisms by which it shapes the HIV epidemic in the specific contexts of different Sub-Saharan African countries.

2.4 HIV Prevalence and Socioeconomic Inequality in Nigeria

As the aforementioned studies indicate, socioeconomic inequality is, in some Sub-Saharan African countries, a greater determinant of HIV infection than poverty itself. (1-3) Importantly however, the existing studies of HIV prevalence and inequality in Sub-Saharan Africa have not included Nigeria (perhaps due to a lack of easily available data, for example through the DHS) (2, 3), although it is a particularly relevant setting in which to investigate this phenomenon given that it is both the most populous country on the African continent (6) and has the second highest absolute number of people living with HIV of any country in the world. (5) Moreover, Nigeria's ethnic diversity and inter-regional heterogeneity (6, 7) provides both an interesting and relevant context in which to investigate questions at the intersection of inequality and health. In addition, regarding HIV specifically, there is significant state-level variation in HIV prevalence in the country, which may be attributable in part to the substantial socioeconomic inequalities and sociocultural differences present between states, (7, 13) however, the association of state-level economic inequality with state-level HIV prevalence has not yet been studied.

CHAPTER THREE: METHODOLOGY

3.1 Data Collection

3.1.1 Paper 1

Data source

This study is based on the 2013 Nigerian Demographic and Health Survey,(6) a nationally representative survey of 38,948 females and 17,359 males in Nigeria, aged 15 to 49 years. The sampling procedure involved a 3-stage sampling design, in which enumeration areas (EAs) were first stratified by urban versus rural location, and were then selected randomly within each stratum. 45 households within each EA were then selected for the survey using equal probability sampling. This 3-stage sampling method was taken into account in the computation of survey weights, applied to ensure the representativeness of the sample with regards to the general population. Data for this study is derived from the individual female and male datasets, merged prior to data analysis (after creating the new variable, sex, to identify the source dataset). The response rates were 95% and 98% for the male and female datasets, respectively,(6) resulting in a total weighted sample size of N = 56307.

Outcome variable and predictors

The outcome variable, HIV-related knowledge, was computed as the sum of correct answers to HIV-related awareness and knowledge questions in the NDHS. For questions assessing HIV-related knowledge, answers were recoded as follows: correct answer = 1, incorrect answer = 0, do not know = 0 (see **Appendix 4.1**). For questions assessing HIV-related awareness (questions 1-3, **Appendix 4.1**), aware = 1, unaware = 0. The resulting total score was then dichotomized into high vs. low HIV-related knowledge using the sample median score as the cut-off. Twelve questions were included in the HIV-related knowledge total score (see **Appendix 4.1**), giving a highest possible score of 12. For a more detailed analysis of different areas of HIV-related knowledge, these 12 questions were then also separated into four knowledge domains (general HIV-related knowledge, knowledge of risk reduction measures, general knowledge of transmission routes, and knowledge of mother-to-child transmission), with total scores again dichotomized into low vs. high according to the median for each domain. Despite the recognized statistical disadvantages of dichotomizing a continuous variable,(41) it remains a common approach for handling questionnaire or score data in the health sciences,(42-44) and has also been used in a similar study investigating a DHS-derived HIV-related knowledge score as the outcome variable.(45) Although the mean

was used in the aforementioned study, the median is used in the current study, as HIV-related knowledge scores in the current sample did not follow a standard distribution.

Based on the aforementioned conceptual framework derived from existing literature on potential predictors of HIV-related knowledge in Nigeria, the variables age, sex, absolute wealth, state-level wealth inequality, educational attainment, literacy, employment status, relationship status, urban/rural dwelling, ethnicity and religion were considered in the investigation of correlates of HIV-related knowledge in this sample.

In the NDHS, national wealth quintiles are calculated based on an asset index of household goods (such as the ownership of livestock). As the continuous wealth score (based on the aforementioned asset index) arises from a principal component analysis and negative values are therefore possible, to calculate state-level wealth inequality, the raw wealth score was first transformed via additive transformation to yield only positive values. These were then sorted by state, and state-level wealth inequality was then computed as the ratio of the lower quintile over the upper quintile. Literacy was recoded from its initial categories into dichotomous categories (literate vs. low literacy level/illiterate/visually impaired), and cases for which a literacy assessment card was unavailable were coded as missing. Individuals with missing data for literacy were found not to differ significantly from those with literacy data on demographic characteristics such as age, sex and employment status, although they were found to be significantly more likely to live in rural areas and in States with high wealth inequality, and were significantly less likely to belong to certain dominant ethnic groups (e.g. Yoruba). (See **Appendix 4.2** for comparison of respondents with missing vs. available literacy data).

3.1.2 Paper 2

Data Source

This study is based on the 2003, 2008, and 2013 Nigerian Demographic and Health Surveys (NDHS),(6, 46, 47) nationally representative surveys of men and women in Nigeria. As the 2013 survey only contained data on respondents aged 15 to 49 years, cases older than 49 years in the 2003 and 2008 datasets were excluded from this analysis, giving total final sample sizes of n= 9713, n=47193, and n=56307 for 2003, 2008, and 2013, respectively. The sampling procedure for the NDHS involved a 3-stage (in 2013) or 2-stage (in 2003 and 2008) sampling design, in which EAs were first stratified by urban versus rural location, and

households were subsequently selected using equal probability sampling. This sampling method was taken into account in the computation of survey weights, applied to ensure the representativeness of the sample with regards to the general population. Data for this study is derived from the individual female and male datasets in each year, merged prior to data analysis (using a variable for sex to identify the source dataset).

Variables Measured

The outcome variable, HIV-related knowledge, was computed as described in the previous section (**3.1.1**). Changes in HIV-related knowledge over time were analysed, stratified by several socioeconomic and demographic factors, based on those found to be significant in **Paper 1** and prior literature. These factors included age, sex, rural or urban residency, literacy level, educational attainment, employment status, ethnicity, religion, absolute wealth, and state-level wealth inequality. Literacy was recoded as described in the previous section, with individuals with no available literacy data coded as missing. Individuals with missing data for literacy were found not to differ significantly from those with literacy data on specific demographic characteristics in some survey years but did in others. For example, in the 2013 and 2003 surveys, respondents with missing data were significantly more likely to reside in rural areas, but this difference was not significant in the 2008 cohort. (See **Appendices 4.2** and **5.1** for comparison of respondents with missing vs. available literacy data in each survey year.)

Absolute wealth was defined using the continuous wealth scores calculated in the NDHS, which are derived from an asset index of household goods (such as the ownership of livestock), and subsequently categorized into quintiles at the national level. State-level wealth inequality was calculated through an additive transformation of the continuous wealth scores to give only positive values,(3) followed by the sorting of transformed scores by state, and the computation of the ratio of the lower over the upper wealth quintile to produce a state-level wealth inequality ratio.

3.1.3 Paper 3

Search Strategy and Study Registration

A literature search of the Embase and Medline databases was conducted in November 2017, using the search term outlined in detail in **Appendix 6.1**. The conduct of this systematic review is reported according to the PRISMA reporting guidelines for systematic reviews and

meta-analyses, (48) and the study protocol is registered on the PROSPERO database, available here.

Eligibility Criteria

Eligibility for inclusion in the review were primary, original research studies published in French or English, reporting on the implementation of a HIV-related knowledge intervention in Sub-Saharan Africa or among the African Diaspora. HIV-related knowledge interventions included any interventions that aimed at improving any aspect of HIV-related knowledge, which could include, for example, knowledge of HIV prevention or transmission, or HIV risk reduction interventions. Excluded studies were those not taking place in Sub-Saharan Africa or among the African diaspora, qualitative studies, those not administering an intervention or program aimed at improving HIV-related knowledge (e.g. cross-sectional studies on HIV-related knowledge, general sexual health interventions not specific to HIV, or assessments of knowledge of HIV status only), or those targeting HIV educational interventions at healthcare providers. Also excluded were conference abstracts, editorials, commentaries, study protocols, news articles, and secondary analyses (e.g. reviews or meta-analyses).

Study Selection

Abstracts were screened according to the aforementioned criteria, and full-texts were retrieved for eligible studies. At full-text review, in addition to the abovementioned criteria, studies were excluded if they did not report quantitative data on at least one of the following outcomes of interest: a) changes in HIV-related knowledge (see **Table 6.1** for included knowledge questions), b) adoption of preventive measures (condom use) or c) HIV incidence.

Data Collection and Risk of Bias Assessment

The Covidence systematic review management platform (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia) was used for study de-duplication and screening. Data extraction was carried out in Microsoft Excel (Version 14.5.5). Risk of bias for RCTs and non-RCTs was assessed using the 9-item Cochrane Risk of Bias Tool (49, 50), and risk of bias in uncontrolled (e.g. one-arm pre-post studies) was assessed based on the Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control. (51) These tools assess the methodological quality of studies based on criteria such as the random allocation of participants to control or intervention groups, blinding of participants and

outcome assessors, cross-contamination of study groups, attrition bias, and bias in outcome reporting.

3.2 Data Analysis

3.2.1 Paper 1

Socio-demographic characteristics of the sample are reported using descriptive statistics. To optimize the representativeness of the sample, weights, as recommended by the DHS, were applied to descriptive analyses. Bivariate analyses were carried out to investigate associations between each predictor variable and the dichotomous outcome variable HIV-related knowledge via the T test for approximately normally distributed continuous variables and X^2 analyses for categorical variables (including the categorical recodes of continuous variables). An α value of 0.05 was considered indicative of statistical significance, except where appropriate Bonferroni corrections were applied.(52) All analyses were conducted in SPPS, version 24.0 (IBM Corp., Armonk, NY), except for the computation of state-level wealth inequalities, which was carried out in Stata, version 14 (StataCorp, College Station, TX), because this computation required features not available in SPSS.

Model variable selection and testing of assumptions

Variables yielding significant p-values in X^2 analysis were considered for inclusion in the initial logistic regression model, with wealth inequality as the focal predictor, adjusting for age, sex, ethnicity, religion, relationship status, rural/urban residence, literacy, absolute wealth and employment status. Variables were tested to determine whether the underlying assumptions of logistic regression were met.(53)

Testing the assumption of the linearity of continuous predictors, Box-Tidwell analysis(53) demonstrated that none of the continuous variables were linearly related to the logit of HIV-related knowledge, (all $p<0.001$) even after a Bonferroni correction was applied to the α value of 0.05,(52) yielding an adjusted α value of 0.004. These continuous variables were therefore recoded into categorical variables. The categorization of age (into 3 categories: 15-24, 25-34 and 35-49 years) took into account the WHO's identification of 15-24 year-olds as a particular high-risk group for STIs. (54)

To test for the absence of multicollinearity, a correlation matrix using Spearman's correlation for ordinal*ordinal associations or Cramer's V (φ_c) for ordinal*nominal and

nominal*nominal associations was carried out. Spearman correlation coefficients > 0.7,(55) and $\varphi_c > 0.5$ were considered strong.(56)Variables whose bivariate relationships had coefficients exceeding these thresholds were therefore considered highly correlated, and variables were thus removed from the model where appropriate.

Lastly, interaction terms were added based on conceptual relevance (for example sex * wealth inequality).(32, 33) The final logistic regression model, comprising the categorical covariates age category, sex, literacy level, employment status, wealth quintile, state-level wealth inequality ratio, relationship status, urban/rural residence, ethnicity, religion, and interaction terms, was therefore of the form:

$$logit\ (p) = ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k. \quad (57)$$

Based on the adjusted odds ratios (AORs) and corresponding confidence intervals derived from this model, the odds of having low HIV-related knowledge in various socio-demographic strata were then interpreted to identify predictors of low HIV-related knowledge in the Nigerian population.

3.2.2 Paper 2

As the distributions of scores for all four HIV-related knowledge domains as well as the overall HIV-related knowledge score were non-normal (3SD > mean) in one or more of the three years, analysis of variance (ANOVA) was not suitable, and thus the Kruskal-Wallis test was applied to determine whether these distributions differed significantly across the three years. The changes in mean scores for each knowledge domain and overall HIV-related knowledge from 2003 to 2013 were then displayed graphically, stratified by the relevant aforementioned socioeconomic and demographic variables. Autoregressive Integrated Moving Average (ARIMA) models were fit to the 2003-2013 trend in HIV-related knowledge for all knowledge domains. Possible predictors were selected for the models based on a prior analysis of socio-demographic determinants of HIV-related knowledge in a forthcoming paper, and were entered into the models individually. The ARIMA models with the most accurate fit (those resulting in the highest R-squared value and lowest mean absolute percentage error (MAPE)) are presented.

3.2.3 Paper 3

For the primary outcome of interest, HIV-related knowledge, data relating to two domains of HIV-related knowledge were extracted: 1) knowledge of HIV risk reduction through condom use 2) knowledge of modes of transmission (through blood and sexual contact). The specific questions for which data were extracted are shown in **Table 6.1**. Data were extracted either as continuous data, in the form of mean knowledge scores, or as categorical data, in the form of proportions of respondents providing correct answers. Secondary outcomes considered in this review were condom use and HIV incidence. Condom use was measured as defined by the study (e.g. proportion always using condoms, proportion using condoms at last sex, or over a specified time period).

For categorical data (e.g. proportion of participants having correct knowledge) meta-analyses were conducted in cases where more than 2 studies reported data for an outcome and provided sufficient information for the calculation of odds ratios. Continuous data, such as mean condom use, are meta-analysed using the mean difference as the effect size measure. Where possible, analyses were grouped by intervention type. All meta-analyses were carried out in R (specifically the metafor package) (58), using a random-effects model.

3.3 Research Ethics

The DHS program (run by USAID) receives research ethics board approval for all data collection procedures it conducts, in accordance with U.S Department of Health and Human Services regulations as well as local Nigerian research ethics requirements. Drawing on this data, the studies conducted within this thesis therefore did not require additional ethics approval. However, in keeping with the DHS program's guidelines of being given access to any studies conducted using DHS data, a report of the results of the analyses presented herein will be provided to the DHS upon completion. Moreover, as per DHS regulations, data extracted from the DHS will be handled as confidential, and study participants will remain unidentified.

3.4 Significance of Results

Elucidating the relationship between wealth inequality and HIV-related knowledge allows the identification of vulnerable groups at which future campaigns for HIV awareness and prevention should be more precisely targeted. Moreover, the analysis of other factors, such as sex, literacy, or age, that may influence HIV-related knowledge, is critical in order to more

appropriately address the barriers that issues such as women's disempowerment represent for the reduction of HIV transmission.

In addition, investigating changes in HIV-related knowledge in Nigeria at the 2003, 2008 and 2013 time points provides an indication of the trend of HIV-related knowledge over time in the country, and, more importantly, how this trend has differed not only over time but also between states and between various sociodemographic groups, identifying groups or regions that should be given increased attention in current efforts towards improving HIV awareness and prevention in the country. The attention given in the present analyses not only to HIV-related knowledge as a whole but to specific sub-domains of HIV-related knowledge, such as knowledge of mother-to-child transmission or risk reduction also provides an evidence base for the emphasis of particular educational content in the design and dissemination of future HIV prevention interventions.

Lastly, the systematic review of HIV-related knowledge interventions and the meta-analysis of the evidence regarding their efficacy in terms of improving HIV-related knowledge, increasing engagement in preventive behaviours, and ultimately reducing HIV incidence identifies which types of interventions have worked to date, and facilitates the evidence-based implementation of these interventions. Importantly, in combination with the results of the analyses in papers 1 and 2, the modification of intervention content or mode of delivery to suit the needs of a particular identified risk group is also facilitated.

CHAPTER FOUR: PAPER 1

Wealth Inequality as a Predictor of HIV-related Knowledge in Nigeria

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4.1 Abstract

Introduction: Considering the high state-level heterogeneity of HIV prevalence and socioeconomic characteristics in Nigeria, it is a relevant setting for studies into the socioeconomic correlates of HIV-related knowledge. Although the relationship between absolute poverty and HIV transmission has been studied, the role of wealth *inequality* in the dynamics of the HIV epidemic has yet to be investigated in Nigeria. The current study, therefore, investigates wealth inequality and other socio-demographic covariates as predictors of HIV-related knowledge, in order to identify subgroups of the Nigerian population that would benefit from HIV preventive interventions.

Methods: This study utilized the nationally representative 2013 Nigerian Demographic and Health Survey (NDHS). HIV-related knowledge was computed as a total score based on HIV-related knowledge indicators in the NDHS, dichotomized using the sample median as the cut-off. Wealth inequality and other relevant socio-demographic variables were introduced into a logistic regression model based on their significance in bivariate analyses. Odds ratios derived from the model were interpreted to identify risk groups for low HIV-related knowledge after adjusting for confounding factors.

Results: The regression model indicated that individuals with lower literacy levels were almost twice as likely as literate respondents to have low HIV-related knowledge (AOR: 1.95, 95%CI: 1.85-2.05, $p<0.001$), and individuals in the upper wealth quintile were less than half as likely than those in the lower wealth quintile to have low HIV-related knowledge (AOR: 0.40, 95% CI: 0.35-0.46, $p<0.001$). Females were also more than twice as likely as males to have low HIV-related knowledge at each level of wealth inequality. In addition, females were 80% less likely to have low mother-to-child transmission knowledge than males, but had over 1.5 times higher odds of having poor knowledge of HIV risk reduction measures. Ethnicity, religious affiliation, relationship status, and residing in rural areas were additional significant predictors of HIV-related knowledge.

Conclusion: HIV-related knowledge in this sample is generally low among females, those with low literacy levels, the poor, the unemployed, those residing in rural areas, those with traditional religious beliefs, and those living in states with the highest wealth inequality ratios. The identification of these risk groups for low HIV-related knowledge facilitates the

implementation of future evidence-based interventions among these groups in order to potentially reduce HIV transmission.

Key Questions:

What is already known about this topic?

- Nigeria exhibits high inter-regional heterogeneity in terms of HIV prevalence and socioeconomic characteristics
- Although associations between absolute wealth and HIV transmission have received considerable attention in the existing literature, more recent Sub-Saharan African studies suggest that wealth inequality may be a more significant predictor of HIV transmission in the region
- The importance of the improvement of HIV-related knowledge as a strategy for HIV prevention is recognized, however, risk groups for low HIV-related knowledge have not yet been investigated in the Nigerian context

What are the new findings?

- HIV-related knowledge is generally low in this population, particularly with regard to the understanding of modes of mother-to-child transmission of HIV
- Important predictors of low HIV-related knowledge in Nigeria include poverty, low literacy, ethnicity, religious affiliation, relationship status, being female under circumstances of wealth inequality, and residing in rural areas

Policy recommendations

- Individuals with incomplete knowledge of HIV risk factors or transmission routes may underestimate their risk of infection, and thus represent a pertinent population subgroup for provider-initiated HIV testing and counselling (which has been shown to be highly feasible in the Nigerian context).(59)
- Educational interventions covering the modes of transmission of HIV and preventive measures should be preferentially targeted at the abovementioned identified risk groups for low HIV-related knowledge.
- In particular, the observed low knowledge of HIV risk reduction among females should be urgently addressed through the targeting of risk reduction interventions at females, with a particular focus on female-controlled preventive measures.

- These interventions should be adapted in terms of both content and mode of delivery to suit the needs of the target population, including for example the dissemination of verbal as opposed to written information to population subgroups with low literacy.

4.2 Background

As Nigeria is both the most populous country in Africa(6) as well as the country with the second highest number of people living with HIV in the world,(5) studies into the epidemiology of HIV in the Nigerian context continue to be pertinent. As of 2013, 9% of the global burden of HIV cases were attributed to Nigeria alone,(5) and in 2014, the country experienced an incidence of 220,000 new HIV cases.(7) A total of 3.5 million people were estimated to be living with HIV in Nigeria as of 2015, and 180,000 deaths were attributed to HIV in the same year.(4) Although the overall prevalence of HIV in Nigeria is estimated at 3.4%,(13) there are wide disparities in HIV prevalence at the state level, ranging from 0.2% in Ekiti to 15.2% in Rivers.(14)

Many studies of HIV epidemiology have focused on absolute poverty as a risk factor for HIV infection,(1) however, in recent years, studies from Sub-Saharan Africa have reported that socioeconomic inequality is a stronger driver of HIV transmission than absolute measures of poverty or wealth.(2, 3, 25, 26) Despite Nigeria's high overall HIV prevalence, its wide disparities in state-level HIV prevalence, and the highly socioeconomically heterogeneous nature of its states, of the few studies that have investigated socioeconomic inequality as a driver of HIV transmission in Sub-Saharan Africa,(2, 3, 25, 26) none have done so in Nigeria.

Although low HIV-related knowledge (and consequently, low risk-perception and potentially higher-risk sexual practices) is considered an important contributory factor to the spread of HIV in Nigeria, detailed studies on how this knowledge differs among socioeconomic fault lines within the country are lacking.(13) Given the country's socioeconomic and cultural heterogeneity,(7) determining the association of wealth inequality and other socio-demographic factors with HIV-related knowledge in Nigeria has the potential to provide valuable insight into the identification of population subgroups that may underestimate or be unaware of their risk of infection, and thus facilitate the evidence-informed design or modification of preventive interventions. Moreover, a previous study in Nigerian indicated high awareness of the existence of HIV, but low awareness of certain modes of transmission,

particularly mother-to-child transmission, suggesting that preventive behaviours regarding such transmission is low.(60) The identification of socio-demographic groups with low HIV-related knowledge in Nigeria may therefore represent an initial step towards the eventual reduction of HIV transmission in the country.

The current study aimed to investigate the association between wealth inequality and other socio-demographic covariates with HIV-related knowledge in order to better understand the factors that drive the Nigerian HIV epidemic.

4.3 Methods

4.3.1 Data source

This study is based on the 2013 Nigerian Demographic and Health Survey,(6) a nationally representative survey of 38,948 females and 17,359 males in Nigeria, aged 15 to 49 years. The sampling procedure involved a 3-stage stratification, in which respondents were first stratified by urban versus rural dwelling, and enumeration areas (EAs) were then selected randomly within each stratum. Lastly, 45 households within each EA were then selected for the survey using equal probability sampling. This 3-stage sampling method was taken into account in the computation of survey weights, applied to ensure the representativeness of the sample with regards to the general population. Data for this study is derived from the individual female and male datasets, merged prior to data analysis. The response rates were 95% and 98% for the male and female datasets, respectively,(6) resulting in a total weighted sample size of N = 56307.

4.3.2 Conceptual Framework

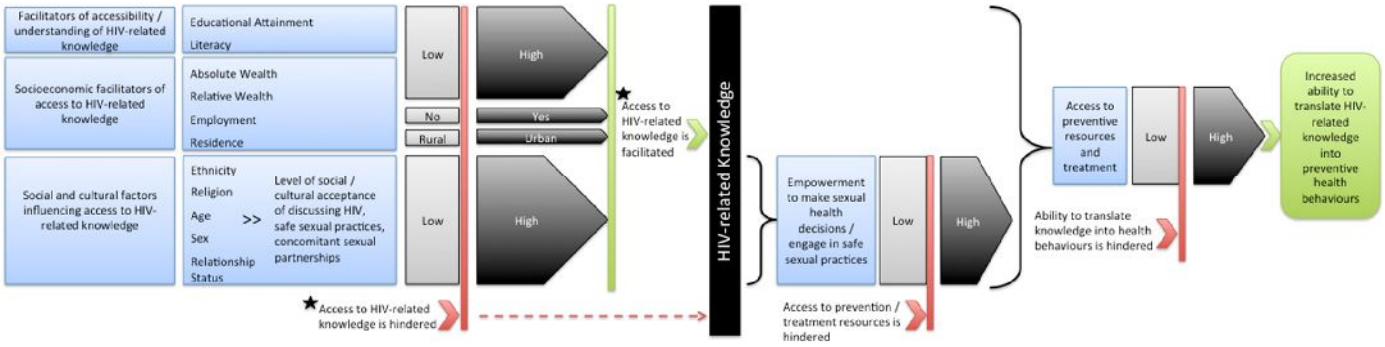
Prior to the examination of socio-demographic predictors of HIV-related knowledge in Nigeria, we present a theoretical framework within which to examine disparities in access to HIV-related knowledge and prevention resources across socio-demographic strata, particularly under circumstances of wealth inequality. The framework contains elements of both the biosocial and the health-belief model. Firstly, the health-belief model,(27) which has served as the conceptual basis of prior studies in the area of health-related knowledge and HIV,(28) argues that an individual's knowledge regarding a disease influences their perception of their risk of contracting it, and in turn their propensity to take preventive measures.(27) Secondly, as underlined by the biosocial perspective and proponents of social medicine, socioeconomic status determines an individual's ability to access health resources,

and the socioeconomically marginalized therefore face structural barriers to accessing these resources, and are consequently at disproportionately high risk of suffering adverse health outcomes.(24, 29, 30)

Combining elements from the two models, we argue here that socio-demographic factors influence not only an individual's access to health information – in this case, to HIV-related knowledge – but also, and importantly, an individual's ability to ultimately transform this information into preventive action in order to actually secure better health outcomes. In addition, we underline that these socio-demographic factors do not necessarily operate in isolation, but rather that the confluence of multiple parameters of socioeconomic marginalization may together determine an individual's risk of low HIV-related knowledge, as well as their ability to use this knowledge to access the preventive health resources. For example, focusing on the relationship between gender and wealth inequality in the context of HIV risk, prior studies have noted that patterns of HIV risk among females compared to males differs across national, regional and economic fault lines, suggesting that the role of gender in HIV risk is influenced by prevailing socio-demographic or socio-economic contexts.(31)

Considering the potential relationship between wealth inequality, gender, and HIV-related knowledge in Nigeria, this suggests that, being subject to the effects of both gender inequities and wealth inequality, women living in poverty may, firstly, have significantly reduced access to HIV education, thus lowering their HIV risk perception and their propensity to adopt preventive measures. Secondly, given that under circumstances of wealth inequality, women may be driven to engage in transactional sex,(32, 33) our model underlines that their marginalization as a result of both their gender and their poverty creates a scenario in which they are less likely to possess the knowledge to identify their risk of infection, the empowerment to put this knowledge into practice (i.e. to negotiate preventive measures with their partner, such as condom use), and the means to actually access the required health resources (condoms, HIV testing, HIV information). **Figure 4.1** provides a diagrammatic representation of the outlined theoretical framework.

Figure 4.1: Theoretical Framework for the Determinants of HIV-Related Knowledge Acquisition and Translation (containing elements of the biosocial model and the health belief model)



★ Denotes relationships investigated in the current study.

4.3.3 Outcome variable and predictors

The outcome variable, HIV-related knowledge, was computed as the sum of correct answers to HIV-related awareness and knowledge questions in the NDHS. For questions assessing HIV-related knowledge, answers were recoded as follows: correct answer = 1, incorrect answer = 0, do not know = 0 (see **Appendix 4.1**). For questions assessing HIV-related awareness (questions 1-3, **Appendix 4.1**), aware = 1, unaware = 0. The resulting total score was then dichotomized into high vs. low HIV-related knowledge using the sample median score as the cut-off. Twelve questions were included in the HIV-related knowledge total score (**Appendix 4.1**), giving a highest possible score of 12. For a more detailed analysis of different areas of HIV-related knowledge, these 12 questions were then also separated into four knowledge domains (general HIV-related knowledge, knowledge of risk reduction measures, general knowledge of transmission routes, and knowledge of mother-to-child transmission), with total scores again dichotomized into low vs. high according to the median for each domain. Despite the recognized statistical disadvantages of dichotomizing a continuous variable,(41) it remains a common approach for handling questionnaire or score data in the health sciences,(42-44) and has also been used in a similar study investigating a DHS-derived HIV-related knowledge score as the outcome variable.(45) Although the mean was used in the aforementioned study, the median is used in the current study, as HIV-related knowledge scores in the current sample did not follow a standard distribution.

Based on the aforementioned conceptual framework derived from existing literature on potential predictors of HIV-related knowledge in Nigeria, the variables age, sex, absolute wealth, wealth inequality, educational attainment, literacy, employment status, relationship status, urban/rural dwelling, ethnicity and religion were considered in the investigation of correlates of HIV-related knowledge in this sample.

In the NDHS, national wealth quintiles are calculated based on an asset index of household goods (such as the ownership of livestock). As the continuous wealth score (based on the aforementioned asset index) arises from a principal component analysis and negative values are therefore possible, to calculate state-level wealth inequality, the raw wealth score was first transformed via additive transformation to yield only positive values. These were then sorted by state, and state-level wealth inequality was then computed as the ratio of the lower quintile over the upper quintile.

4.3.4 Data analysis

Socio-demographic characteristics of the sample are reported using descriptive statistics. To optimize the representativeness of the sample, weights, as recommended by the DHS, were applied to descriptive analyses. Bivariate analyses were carried out to investigate associations between each predictor variable and the dichotomous outcome variable HIV-related knowledge via the T test for approximately normally distributed continuous variables and X^2 analyses for categorical variables (including the categorical recodes of continuous variables).

An α value of 0.05 was considered indicative of statistical significance, except where appropriate Bonferroni corrections were applied.(52) All analyses were conducted in SPPS, version 24.0 (IBM Corp., Armonk, NY), except for the computation of state-level wealth inequalities, which was carried out in Stata, version 14 (StataCorp, College Station, TX), because this computation required features not available in SPSS.

4.3.5 Model variable selection and testing of assumptions

Variables yielding significant p-values in X^2 analysis were considered for inclusion in the initial logistic regression model, with wealth inequality as the focal predictor, adjusting for age, sex, ethnicity, religion, relationship status, rural/urban residence, literacy, absolute wealth and employment status. Variables were tested to determine whether the underlying assumptions of logistic regression were met.(53)

Testing the assumption of the linearity of continuous predictors, Box-Tidwell analysis(53) demonstrated that none of the continuous variables were linearly related to the logit of HIV-related knowledge, (all $p<0.001$) even after a Bonferroni correction was applied to the α value of 0.05,(52) yielding an adjusted α value of 0.004. These continuous variables were therefore recoded into categorical variables.

To test for the absence of multicollinearity, a correlation matrix using Spearman's correlation for ordinal*ordinal associations or Cramer's V (φ_c) for ordinal*nominal and nominal*nominal associations was carried out. Spearman correlation coefficients > 0.7,(55) and $\varphi_c > 0.5$ were considered strong.(56).Variables whose bivariate relationships had coefficients exceeding these thresholds were therefore considered highly correlated, and variables were thus removed from the model where appropriate.

Lastly, interaction terms were added based on conceptual relevance (for example sex * wealth inequality).(32, 33) Based on the adjusted odds ratios (AORs) and corresponding confidence intervals derived from this model, the odds of having low HIV-related knowledge in various socio-demographic strata were then interpreted to identify predictors of low HIV-related knowledge in the Nigerian population.

4.3.6 Research ethics approval

The DHS program obtains informed consent from participants and ensures their anonymity in accordance with U.S Department of Health and Human Services regulations. In addition, the Nigerian DHS is conducted according to local Nigerian research ethics requirements. Data for this analysis were accessed via the publicly available DHS datasets, with access granted through the DHS program. As this was a secondary data analysis, further research ethics approval was not required, however, in accordance with DHS regulations, all data extracted from the NDHS for the purpose of this study were handled as confidential and survey respondents remained unidentified. This study conforms to the principles of the Declaration of Helsinki.

4.4 Results

4.4.1 Sample characteristics and HIV-related knowledge

The complete surveys constituted a total sample of n=56,307 (69.2% female), with respondents aged 15-49 years (mean age (years): 28.91, SD: 9.689). 39.4% of the sample had

completed secondary education, 32.7% had no formal education at any level, and only 10.7% had post-secondary education. The majority of the study population resided in a rural area (57.3%). Further socio-demographic characteristics of the study population are shown in **Table 4.1.**

The study population had limited HIV-related knowledge, with a median HIV-related knowledge score of 9 (IQR: 7-11) out of 12. Notably, 6.7% of the sample had never heard of AIDS, and only 11.5% of respondents correctly answered all 12 HIV-related knowledge questions. Knowledge of the possible modes of mother-to-child transmission of HIV was average in this sample, with 58.4, 58.2, and 69.0% of respondents reporting knowing that HIV can be transmitted during pregnancy, delivery, or breastfeeding, respectively. Bivariate analyses for the associations of socio-demographic characteristics with HIV-related knowledge are provided in **Table 4.1, and** proportions of correct responses for each question are shown in **Table 4.2**.

Table 4.1. Socio-demographic characteristics of the study population, and bivariate analyses of associations with HIV-related knowledge

Socio-demographic Variable	**N (valid %)** (Unless otherwise indicated)	**Percent of demographic group with Low [a] HIV-related knowledge (%)**	**p value [b]**
Total	56307	41.0	
Age (years)			
15-24	21088 (37.5)	46.1	<0.001
25-34	17783 (31.6)	36.4	
35-49	17436 (31.0)	39.6	
Mean age ± SD	28.91 ± 9.689		
[Range]	[15-49]		
Sex			
Female	38948 (69.2)	43.8	<0.001
Male	17359 (30.8)	35.0	
Highest level of educational attainment			
No formal education	18414 (32.7)	64.1	<0.001
Primary education	9640 (17.1)	43.2	
Secondary education	22208 (39.4)	33.0	
Post-secondary education	6044 (10.7)	12.5	
Literacy Level (n=55896)			
Illiterate, low literacy level, or visually impaired	26354 (47.1)	57.0	<0.001

Literate	29542 (52.9)	28.8	
Employment status (n=56025)			
Unemployed	18720 (33.4)	47.4	<0.001
Employed	37305 (66.6)	37.9	
Region of Residence			
Urban	24026 (42.7)	30.0	<0.001
Rural	32281 (57.3)	49.1	
Ethnicity [c]			
Fulani	3518 (6.2)	65.5	<0.001
Hausa	15417 (27.4)	55.6	
Ibibio	1261 (2.2)	32.1	
Igbo	7967 (14.1)	31.4	
Ijaw	1097 (1.9)	23.4	
Yoruba	7823 (13.9)	29.3	
Other	19225 (34.1)	38.7	
Religion			
Catholicism	6329 (11.2)	32.4	<0.001
Other Christian	20102 (35.7)	30.1	
Islam	29057 (51.6)	52.5	
Traditionalism	521 (0.9)	62.3	
Other or none	298 (0.5)	39.7	
Relationship status			
Never in union	17704 (31.4)	38.4	<0.001
Currently in union or co-habiting	36552 (64.9)	42.5	
Formerly in union or co-habiting	2051 (3.6)	38.1	
National Wealth Quintile			
Lowest 20th	9994 (17.7)	69.1	<0.001
20th-40th	10420 (18.5)	53.7	
40th-60th	10824 (19.2)	41.2	
60th-80th	11827 (21.0)	32.2	
Highest 20th	13242 (23.5)	21.7	
State-Level Wealth Inequality Ratio Category			
<1.50	8012 (14.2)	28.5	<0.001
1.50 - 1.79	20629 (36.6)	41.0	
1.80 - 2.19	25578 (45.4)	46.0	
> 2.19	2088 (3.7)	39.0	
HIV-Related Knowledge Score (median [IQR]) [d] (N=51530)	9 [7-11]		

[a] below sample median (< 9)

[b] p-values determined by X^2 tests

[c] Specific ethnic groups shown are those with >1000 members

[d] Highest possible total score = 12

Table 4.2. Proportion of respondents with correct knowledge or awareness of HIV-related knowledge indicators in each knowledge domain

Knowledge Area	NDHS HIV-related knowledge question	N correct or N aware* (valid %)
General HIV-related knowledge	Has heard of AIDS * (n=56285)	52509 (93.3)
	A healthy looking person can have HIV (n=52155)	39470 (81.3)
	Knows a place to get HIV testing * (n=52434)	36136 (68.9)
Knowledge of HIV risk reduction	To reduce the risk of getting HIV: have one sex partner only, who has no other partners (n=52428)	44817 (85.5)
	To reduce the risk of getting HIV: always use condoms during sex (n=52399)	35353 (67.5)
	Knows a source for condoms * (n=56122)	32471 (57.9)
Knowledge of modes of transmission	Can contract HIV from mosquito bite (n=52472)	36975 (70.5)
	Can contract HIV by sharing food with person who has AIDS (n=52420)	42620 (81.3)
	Can contract HIV by witchcraft or supernatural means (n=52374)	36328 (69.4)
Knowledge of mother-to-child transmission	HIV can be transmitted during pregnancy (n=52482)	30673 (58.4)
	HIV can be transmitted during delivery (n=52472)	30547 (58.2)
	HIV can be transmitted by breastfeeding (n=52476)	36221 (69.0)

4.4.2 Bivariate analyses of associations of socio-demographic characteristics with HIV-related knowledge

Bivariate analyses of the association of all categorical independent variables with HIV-related knowledge were found to be significant via X^2 tests ($p<0.001$). Based on these analyses, it was found that the proportion of low HIV-related knowledge was significantly higher among respondents aged 15-24 years than among older age groups, among females than males, among the unemployed than the employed, and among those living in rural compared to urban areas. In addition, the proportion of respondents with low HIV-related knowledge decreased with each additional level of educational attainment, and similarly, a decrease in the proportion of respondents with low HIV-related knowledge was observed at each level from the lower 20th to upper 20th wealth quintiles. Lastly, proportions of low HIV-related knowledge also differed significantly among ethnic and religious groups, literacy levels, and wealth inequality categories. Results of the bivariate analyses are provided in **Table 4.1**.

T tests were carried out for the continuous variables age and wealth inequality, both demonstrating significant differences by HIV-related knowledge category (age: $t=-14.429$, $p<0.001$, wealth inequality: $t= 23.191$, $p<0.001$).

4.4.3 Multicolinearity Testing

Due to its high colinearity with literacy (r_s=0.877), educational attainment was removed from the model, as literacy may be a more accurate representation of an individual's understanding of HIV-related information than educational level, as the latter may be more subjective, given that the quality of education at each level or the classification of these levels may vary across the country. Additionally, urban/rural residence was found to be strongly associated with wealth quintile (df =1, φ_c= 0.586), however, in this case, both variables were retained in the model, given that the effects of urban/rural residence on HIV-related knowledge may in some ways be independent of the effects of wealth on HIV-related knowledge, representing an additional and unique barrier in terms of access to information, for example through lower coverage of HIV awareness campaigns in rural compared to urban areas, regardless of wealth status. Educational attainment was therefore the only variable removed in response to multicollinearity testing.

4.4.4 Predictors of HIV-related knowledge in Nigeria

Literacy level, employment status, relationship status, age category, urban/rural residence, sex, ethnicity, wealth quintile, state-level wealth inequality ratio category, and religion were all predictive of HIV-related knowledge, and the final logistic regression model was found to be statistically significant (p<0.001), correctly predicting the HIV-related knowledge category of 68.1% of all cases. In comparison, the null model, containing only the constant, correctly classified 59.0% of the cases.

Respondents living in urban areas had approximately 20% lower odds of having low HIV-related knowledge compared to residents of rural areas (AOR: 0.83, 95%CI: 0.79-0.87, p<0.001) (**Table 4.3**). Moreover, respondents in the youngest age category (15-24 years) had significantly higher odds of having low HIV-related knowledge than respondents in the oldest age category (35-49 years) (AOR: 1.35, 95%CI: 1.22-1.49, p<0.001). In addition, respondents reporting being Traditionalist had significantly higher odds of low HIV-related knowledge than any other religious category (Catholics: AOR: 0.48, 95%CI: 0.38-0.60, p<0.001; other Christians: AOR: 0.49, 95%CI: 0.39-0.60, p<0.001). Respondents with low literacy levels were almost twice as likely as literate respondents to have low HIV-related knowledge (AOR: 1.95, 95%CI: 1.85-2.05, p<0.001).

Respondents in the upper 20th wealth quintile were more than two times less likely to have low HIV-related knowledge as those in the lower 20th wealth quintile (AOR: 0.40, 95% CI: 0.35-0.46, p<0.001), and the odds of low HIV-related knowledge rose significantly (p<0.001) in each wealth category as wealth decreased.

Sex alone was not a significant predictor of HIV-related knowledge overall in this model (p=0.09), however, interaction terms show that females were more than twice as likely as males to have low HIV-related knowledge in lower wealth inequality categories than males in the highest wealth inequality category (**Figure 4.2)**. Across the first three wealth inequality categories, the sex * wealth inequality interaction plot demonstrates a steeper rise in the probability of low HK for females than for males as wealth inequality increases, and the overall probability of having low HIV-related knowledge is higher for females than for males at each level of wealth inequality. However, the probability of low HIV-related knowledge decreases considerably from the second highest to highest wealth inequality categories among females, even falling below that of males.

Table 4.3. Logistic regression model for the prediction of HIV-related knowledge in Nigeria

Variable	AOR	95% CI		p value	OR	95% CI		p value
		Lower	Upper			Lower	Upper	
Ethnicity								
(Yoruba) [a]								
Other	0.94	0.87	1.00	0.066	1.53	1.44	1.62	0.000
Fulani	1.15	1.02	1.29	0.020	4.58	4.17	5.03	0.000
Hausa	0.97	0.89	1.05	0.407	3.03	2.85	3.22	0.000
Ibibio	0.96	0.83	1.11	0.572	1.14	1.00	1.30	0.047
Igbo	1.00	0.92	1.09	0.991	1.10	1.03	1.18	0.005
Ijaw	0.59	0.52	0.68	0.000	0.74	0.66	0.82	0.000
Religion								
(Traditionalism) [a]								
Other or none	0.58	0.40	0.83	0.003	0.40	0.29	0.55	0.000
Catholicism	0.48	0.38	0.60	0.000	0.29	0.23	0.36	0.000
Other Christian	0.49	0.39	0.60	0.000	0.26	0.21	0.32	0.000
Islam	0.72	0.57	0.89	0.003	0.67	0.54	0.82	0.000
Region of Residence								
(Rural) [a]								
Urban	0.83	0.79	0.87	0.000	0.44	0.43	0.46	0.000
National Wealth Quintile								
(Lower 20th) [a]								
20th-40th	0.66	0.59	0.74	0.000	0.52	0.49	0.55	0.000

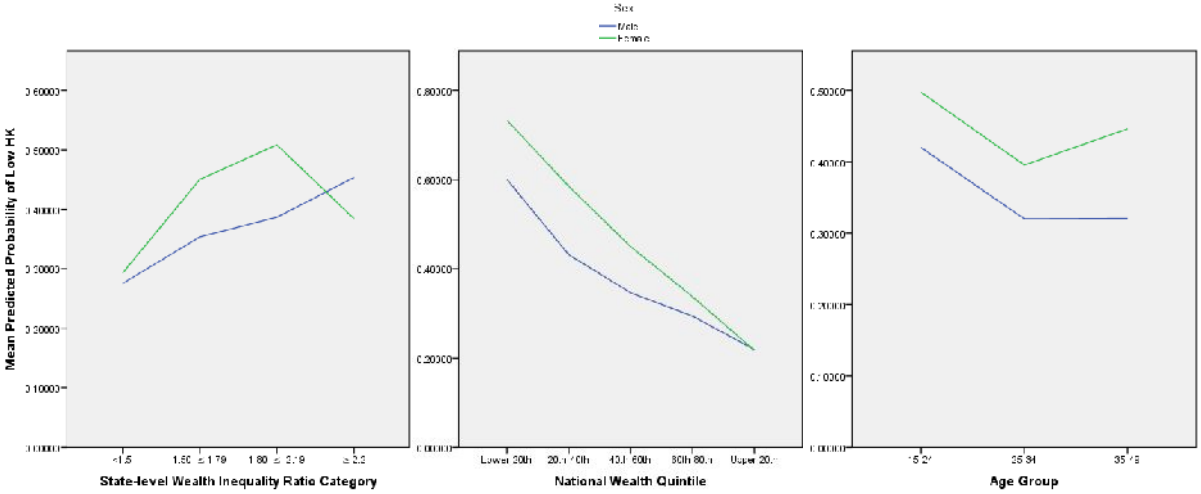
40th-60th	0.58	0.51	0.65	0.000	0.31	0.29	0.33	0.000
60th-80th	0.52	0.46	0.59	0.000	0.21	0.20	0.23	0.000
Upper 20th	0.40	0.35	0.46	0.000	0.12	0.12	0.13	0.000
Relationship Status								
(Never in union) [a]								
Currently in union or cohabiting	0.78	0.74	0.83	0.000	1.19	1.14	1.23	0.000
Formerly in union or cohabiting	0.78	0.70	0.88	0.000	0.99	0.90	1.09	0.845
Current Employment Status								
(Employed) [a]								
Unemployed	1.28	1.22	1.34	0.000	1.47	1.42	1.53	0.000
Sex								
(Male) [a]								
Female	0.77	0.57	1.04	0.090	1.45	1.39	1.50	0.000
State-level Wealth Inequality Ratio Category								
(> 2.19) [a]								
< 1.5	1.09	0.85	1.40	0.489	0.63	0.55	0.72	0.000
1.5 - 1.79	1.05	0.83	1.32	0.689	1.09	0.96	1.24	0.200
1.80 - 2.19	0.91	0.73	1.15	0.427	1.33	1.17	1.52	0.000
Age Group								
(35-49) [a]								
15-24	1.35	1.23	1.49	0.000	1.30	1.25	1.36	0.000
25-34	1.02	0.94	1.12	0.609	0.87	0.83	0.91	0.000
Literacy Level								
(Literate) [a]								
Low literacy or visually impaired	1.95	1.85	2.05	0.000	3.27	3.16	3.40	0.000
Age * Sex								
(35-49 * Male) [a]								
15-24 * Female	0.94	0.85	1.04	0.252	1.50	1.44	1.57	0.000
25-34 * Female	0.82	0.74	0.91	0.000	1.00	0.96	1.05	0.949
Sex * Wealth Quintile								
(Male * Lower 20th) [a]								
Female * 20-40th	0.94	0.82	1.08	0.385	1.74	1.64	1.84	0.000
Female * 40-60th	0.78	0.68	0.89	0.000	0.99	0.94	1.05	0.762
Female * 60-80th	0.65	0.57	0.75	0.000	0.63	0.59	0.66	0.000
Female * Upper 20th	0.56	0.49	0.65	0.000	0.34	0.32	0.36	0.000
Sex * Wealth Inequality Ratio Category								
(Male * >2.19) [a]								
Female * <1.5	2.36	1.74	3.21	0.000	0.76	0.71	0.81	0.000
Female * 1.5-1.79	2.51	1.87	3.35	0.000	1.46	1.39	1.52	0.000
Female * 1.80-2.19	2.58	1.93	3.44	0.000	1.84	1.76	1.93	0.000

[a] Reference category

AOR = Adjusted Odds Ratio OR = Unadjusted (crude) Odds Ratio

Variables adjusted for: Ethnicity, Religion, Region of Residence, National Wealth Quintile, Relationship Status, Employment Status, Sex, State-level Wealth Inequality Ratio, Age Group, Literacy Level, Age * Sex, Sex * Wealth Quintile, Sex * Wealth Inequality Ratio

Figure 4.2: Interaction Plots: Predicted Probabilities of Low HIV-related Knowledge by Age * Sex, Sex * Absolute Wealth, and Sex * Wealth Inequality



4.4.5 Predicting Specific Domains of HIV-related Knowledge: Mother-to-Child Transmission, Other Routes of Transmission, and Risk Reduction

The analyses of the odds of low knowledge of mother-to-child transmission (MTCT) (**Table 4.4**) revealed that females are 80% less likely to have low knowledge of mother-to-child transmission of HIV than males (AOR: 0.23, 95%CI: 0.17-0.31, p<0.001), but over 1.5 times as likely as males to have low knowledge of risk reduction measures (AOR: 1.58, 95%CI: 1.14-2.18, p<0.006). The odds of low knowledge of MTCT are highest among the Fulani, and lowest among the Ijaw ethnic groups (Fulani: AOR: 1.13, 95%CI: 1.01-1.26, p<0.028, Ijaw: AOR: 0.54, 95%CI: 0.47-0.61, p<0.001).

The odds of low knowledge of MTCT were approximately 20-30% lower in the 4 upper wealth quintiles compared to the lowest quintile (AORs (range): 0.70-0.77, all p<0.001), and the odds of low knowledge of other routes of transmission decreased by 20% to more than 50% with increasing wealth quintiles. Similarly, those in the 20th to 40th wealth quintile are more than 30% less likely to have low knowledge of risk reduction than those in the lowest

quintile, and these odds of low knowledge decrease with each increase in wealth quintile (all p <0.001). In states with lower wealth inequality, the odds of low knowledge of MTCT were approximately 60-70% lower than in states in the highest wealth inequality category. Furthermore, the odds of low knowledge of risk reduction are between approximately 30% to more than 50% lower in the four lower wealth inequality categories compared to the highest wealth inequality category.

Additionally, the odds of low knowledge of risk reduction are 20% lower among urban dwellers in comparison to rural dwellers, (AOR: 0.80, 95%CI: 0.75-0.85, p<0.001) while the odds of knowledge of MTCT and other transmission modes are similar among rural compared to urban dwellers. On the other hand, with regard to age, respondents in the youngest age group (15-24 years) have greater odds of low knowledge than older respondents across all knowledge domains, and should thus be a priority target for HIV education. Lastly, those with low literacy levels were approximately twice as likely to have low knowledge of risk reduction and 1.5 times as likely to have low knowledge of modes of transmission in comparison to the literate, suggesting that individuals with low literacy face significant barriers to the acquisition of HIV-related knowledge.

Plots of the interaction terms for each of the knowledge domains are shown in **Figure 4.3.** Regarding MTCT, the wealth inequality * sex interaction plot shows that the odds of low knowledge of MTCT are higher in males at all levels of wealth inequality, and that among males, these odds of low knowledge increase as wealth inequality increases. Among females however, the odds of low knowledge increase as wealth inequality increases, until the highest wealth inequality category, at which the odds of low knowledge decrease. Furthermore, as absolute wealth rises, the odds of low knowledge of MTCT decrease among both men and women for each wealth quintile. Interestingly however, men's probability of low knowledge of MTCT does not decrease to the same level as that of females in the highest wealth quintile, which may be expected given that women may be more specifically targeted for MTCT interventions, for example as part of antenatal care.

The interaction plots for risk reduction show that females have a higher probability of low knowledge of risk reduction than males at any category of wealth inequality, and the likelihood of low knowledge rises for both sexes as wealth inequality rises. Similarly, concerning absolute wealth, females are more likely than males to have low knowledge of

risk reduction in each wealth quintile, and this likelihood decreases as their wealth increases. Notably, the decrease in probability of low knowledge at each higher level of wealth is more pronounced in males than in females. Conversely however, for knowledge of other modes of transmission, the probability of low knowledge decreases from the lowest to highest wealth inequality categories for both males and females, suggesting that high wealth inequality may impact access to some but not all domains of HIV-related knowledge.

Across all knowledge domains and in both men and women, the odds of low knowledge are decrease in the 25-34 year old age group, with females having a higher probability of low knowledge in the general knowledge and risk reduction domains, but a lower probability of low knowledge of MTCT at each age group.

Table 4.4. Logistic Regression for the Prediction of Four HIV-Related Knowledge Domains

Variable	Knowledge of Mother To Child Transmission				Knowledge of Risk Reduction				General Knowledge of HIV				Understanding of Routes of Transmission			
	AOR	95% CI		P-value	AOR	95% CI		P-value	AOR	95% CI		P-value	AOR	95% CI		P-value
		Lower	Upper			Lower	Upper			Lower	Upper			Lower	Upper	
Ethnicity (Yoruba) [a]																
Other	0.96	0.89	1.02	0.196	0.97	0.88	1.06	0.514	0.82	0.77	0.88	0.000	1.04	0.98	1.11	0.234
Fulani	1.13	1.01	1.26	0.028	1.53	1.34	1.73	0.000	1.15	1.03	1.29	0.016	0.73	0.66	0.82	0.000
Hausa	0.91	0.84	0.99	0.024	1.32	1.19	1.46	0.000	1.44	1.33	1.57	0.000	0.44	0.41	0.48	0.000
Ibibio	0.92	0.79	1.06	0.232	1.17	0.98	1.41	0.084	0.66	0.57	0.77	0.000	1.43	1.25	1.64	0.000
Igbo	0.96	0.88	1.04	0.332	1.41	1.26	1.57	0.000	2.22	2.04	2.41	0.000	0.76	0.70	0.82	0.000
Ijaw	0.54	0.47	0.61	0.000	0.87	0.75	1.03	0.098	0.62	0.55	0.71	0.000	0.98	0.88	1.09	0.674
Religion (Traditionalism) [a]																
Other or none	0.79	0.56	1.12	0.187	0.70	0.47	1.03	0.067	0.70	0.49	1.00	0.048	0.81	0.58	1.14	0.226
Catholicism	0.73	0.59	0.91	0.004	0.36	0.28	0.45	0.000	0.62	0.49	0.77	0.000	0.84	0.68	1.05	0.128
Other Christian	0.70	0.57	0.86	0.001	0.47	0.38	0.59	0.000	0.61	0.49	0.75	0.000	0.78	0.63	0.96	0.020
Islam	1.04	0.85	1.29	0.692	0.77	0.61	0.96	0.021	0.79	0.63	0.98	0.033	0.74	0.59	0.91	0.005
Region of Residence (Rural) [a]																
Urban	0.92	0.88	0.97	0.001	0.80	0.75	0.85	0.000	0.81	0.77	0.85	0.000	0.93	0.89	0.98	0.003
National Wealth Quintile (Lower 20^{th}) [a]																
20^{th}-40^{th}	0.77	0.69	0.86	0.000	0.67	0.58	0.77	0.000	0.73	0.65	0.82	0.000	0.80	0.72	0.90	0.000
40^{th}-60^{th}	0.70	0.63	0.79	0.000	0.45	0.38	0.52	0.000	0.67	0.59	0.75	0.000	0.83	0.74	0.93	0.002

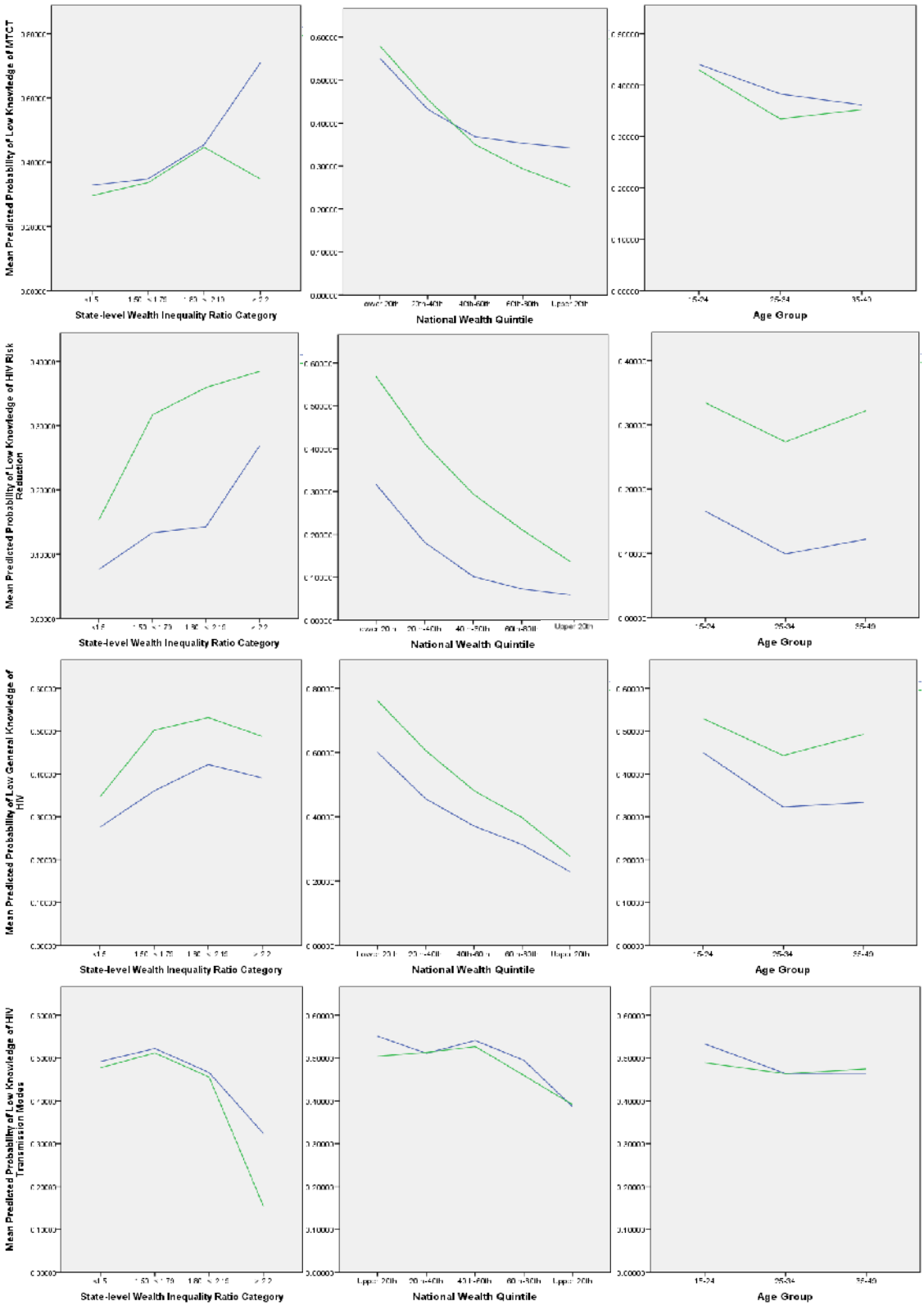
60th-80th	0.73	0.65	0.82	0.000	0.36	0.30	0.42	0.000	0.57	0.50	0.64	0.000	0.70	0.62	0.79	0.000
Upper 20th	0.75	0.66	0.85	0.000	0.35	0.29	0.42	0.000	0.40	0.35	0.46	0.000	0.46	0.41	0.52	0.000
Relationship Status (Never in union) [a]																
Currently in union or cohabiting	0.74	0.70	0.79	0.000	0.80	0.74	0.86	0.000	0.85	0.80	0.90	0.000	0.99	0.94	1.05	0.749
Formerly in union or cohabiting	0.81	0.72	0.91	0.000	0.67	0.58	0.76	0.000	0.83	0.74	0.92	0.001	1.02	0.92	1.13	0.707
Employment Status (Employed) [a]																
Unemployed	1.22	1.17	1.28	0.000	1.17	1.11	1.23	0.000	1.48	1.41	1.55	0.000	0.90	0.86	0.94	0.000
Sex (Male) [a]																
Female	0.23	0.17	0.31	0.000	1.58	1.14	2.18	0.006	1.67	1.23	2.25	0.001	0.36	0.26	0.51	0.000
State-level Wealth Inequality Ratio (> 2.19) [a]																
< 1.5	0.31	0.24	0.40	0.000	0.72	0.53	0.98	0.034	1.08	0.84	1.38	0.569	3.20	2.49	4.12	0.000
1.5 - 1.79	0.31	0.25	0.40	0.000	0.64	0.49	0.83	0.001	0.99	0.78	1.25	0.906	3.01	2.37	3.82	0.000
1.80 - 2.19	0.39	0.31	0.50	0.000	0.46	0.35	0.60	0.000	1.12	0.89	1.41	0.337	2.63	2.07	3.33	0.000
Age Group (35-49) [a]																
15-24	1.08	0.99	1.19	0.101	1.37	1.20	1.55	0.000	1.45	1.31	1.59	0.000	1.46	1.34	1.60	0.000
25-34	1.02	0.94	1.11	0.608	0.83	0.72	0.94	0.005	0.98	0.90	1.07	0.685	1.07	0.99	1.16	0.106
Literacy Level (Literate) [a]																
Illiterate, low literacy or visually impaired	1.37	1.30	1.44	0.000	1.95	1.84	2.08	0.000	1.90	1.80	2.00	0.000	1.49	1.42	1.57	0.000

Age * Sex (35-49 * Male) [a]																
15-24 * Female	1.17	1.06	1.29	0.001	0.81	0.71	0.92	0.001	0.80	0.72	0.88	0.000	0.86	0.78	0.94	0.001
25-34 * Female	0.91	0.82	1.00	0.060	0.98	0.84	1.13	0.745	0.86	0.77	0.95	0.004	0.98	0.89	1.08	0.697
Sex * Wealth Quintile (Male * Lower 20th) [a]																
Female * 20-40th	0.91	0.80	1.05	0.194	1.05	0.90	1.22	0.549	0.81	0.70	0.93	0.003	1.14	0.99	1.30	0.061
Female * 40-60th	0.74	0.65	0.85	0.000	1.25	1.06	1.48	0.009	0.67	0.58	0.77	0.000	1.05	0.92	1.20	0.465
Female * 60-80th	0.60	0.52	0.68	0.000	1.29	1.08	1.54	0.006	0.66	0.57	0.76	0.000	0.98	0.86	1.12	0.797
Female * Upper 20th	0.51	0.45	0.59	0.000	1.03	0.85	1.25	0.753	0.64	0.55	0.74	0.000	1.20	1.05	1.37	0.008
Sex * Wealth Inequality Ratio Category (Male * >2.19) [a]																
Female * <1.5	6.30	4.63	8.57	0.000	1.35	0.95	1.93	0.095	1.43	1.05	1.93	0.022	2.44	1.74	3.43	0.000
Female * 1.5-1.79	5.15	3.84	6.90	0.000	1.89	1.38	2.59	0.000	1.52	1.14	2.03	0.004	2.50	1.80	3.47	0.000
Female * 1.80-2.19	5.02	3.75	6.72	0.000	2.16	1.58	2.95	0.000	1.21	0.91	1.61	0.198	2.44	1.76	3.38	0.000

Variables adjusted for: Ethnicity, Religion, Region of Residence, National Wealth Quintile, Relationship Status, Employment Status, Sex, State-level Wealth Inequality Ratio, Age Group, Literacy Level, Age * Sex, Sex * Wealth Quintile, Sex * Wealth Inequality Ratio

[a] Reference category

Figure 4.3: Interaction Plots: Predicted Probabilities of Low Knowledge Across Four Knowledge Domains



4.5 Discussion

The study found higher odds of low HIV-related knowledge with decreasing wealth category, similar to a previous study indicating absolute poverty as a risk factor for HIV transmission.(1) This finding suggests that a possible contributory factor giving rise to this relationship between poverty and HIV transmission, in particular in the Nigerian context, may be the comparatively low level of HIV-related knowledge among poorer strata of the population, leading to lower engagement in preventive behaviours and consequently a higher likelihood of HIV transmission in this group. The implications of this are that HIV-related knowledge may be a relevant factor influencing relationships between other socio-demographic risk factors and HIV transmission. As HIV-related knowledge is a targetable factor for strategic HIV prevention interventions, the low levels of HIV-related knowledge observed in the current study among the poor suggest that educational interventions to improve HIV-related knowledge should be preferentially targeted at marginalized population subgroups.

Although the authors hypothesized that wealth inequality may be a more significant predictor of HIV-related knowledge in Nigeria than absolute wealth, as studies in other Sub-Saharan African countries have indicated that high wealth inequality is associated with a higher risk of HIV transmission(2, 3, 25, 26), the current study reports similar odds of low overall HIV-related knowledge across wealth inequality categories. However, importantly, when exploring the interaction effect of wealth inequality with sex, the finding that females have more than twice the odds of low overall HIV-related knowledge in comparison to males at all levels of wealth inequality suggests that women are more vulnerable to poor HIV-related knowledge, and by extension less able to advocate for preventive measures, under circumstances of wealth inequality. Moreover, the observation that the rise in the probability of low HK for females is more pronounced than that of males suggests that the effect of wealth inequality on access to HIV-related knowledge is influenced by gender. As suggested by our conceptual model, this indicates that the socioeconomic marginalization experienced as a result of gender and wealth inequality represents a barrier to accessing HIV-related knowledge. As women may experience the combined effects of both gender-related and poverty-related marginalization, they are not only less likely to have access to HIV-related information, but also less likely to have the economic means and social empowerment to turn any acquired HIV-related knowledge into preventive health behaviours.

On the other hand, the fact that the probability of low HIV-related knowledge decreases at the highest wealth inequality category, becoming even lower for females than males in the same category requires further exploration, particularly with regard to the prevailing HIV awareness and prevention programs in high-wealth-inequality states.

The fact that the decrease in probability of low HIV-related knowledge at each increasing national wealth quintile is more pronounced in males than in females (as was seen in the risk reduction knowledge domain and overall HIV-related knowledge interaction plots) suggests that females do not experience the protective effect of absolute wealth on HIV-related knowledge to the same extent as men, highlighting again that females face additional barriers to accessing HIV-related knowledge. These differences in results by sex indicate that apart from sex, the interaction effects of related covariates such as gender inequality or women's empowerment on the relationship between HIV-related knowledge and wealth inequality should be explored, given that previous studies have highlighted women's disempowerment(35, 37), as well as the confluence of inequalities of gender and wealth(32) as significant social correlates of HIV infection in Nigeria.

Considering the observed low knowledge levels regarding the modes of mother-to-child transmission (MTCT) of HIV in the overall sample, it is interesting to note that females displayed significantly lower odds of low HIV-related knowledge than males for the MTCT knowledge domain. This suggests that the observed low overall levels of MTCT knowledge may be attributable to men's low knowledge. Considering that MTCT remains a significant source of new HIV cases in Nigeria, with an approximate 27.3% of pregnant HIV positive women in Nigeria transmitting their infection to their child in 2014,(13) the relatively high knowledge of MTCT among women suggests that although women are aware of the risks of perinatal HIV transmission, they continue to face barriers to adopting preventive measures. This may be due to being unable to advocate for preventive measures or acquire adequate prenatal care in the context of unequal gender dynamics with their male partner,(33) or economic or geographic barriers to MTCT prophylaxis. Moreover, although females in this sample had higher knowledge of MTCT than males, females were significantly more likely than males to have poor knowledge of risk reduction measures, which indicates that MTCT educational interventions may have been successful at improving women's knowledge in this area, but that the provision of specific educational programming for women regarding risk

reduction should be increased, with an emphasis on female-driven preventive options (for example pre-exposure prophylaxis).

Furthermore, given the significantly higher odds of low HIV-related knowledge among respondents with traditional religious beliefs, it is pertinent to consider HIV awareness programs targeted at this group, and the appropriate adaptation of these programs to traditional Nigerian religious and cultural values in order to improve program acceptability.(61) In addition, the drop in probability of low HIV-related knowledge in the 25-34 year old age group compared to the high probability of low HIV-related knowledge in the 15-24 year old group suggests the increased need for earlier HIV education among the younger population, particularly to ensure that HIV-related knowledge is high before sexual debut, rather than retrospectively. The analysis of the specific knowledge domains indicates that a particular focus on HIV risk reduction and prevention of MTCT programming is needed among this age group.

Lastly, those with low literacy levels being found almost twice as likely to have low HIV-related knowledge in comparison to literate respondents not only reiterates the need to target socioeconomically disadvantaged subgroups of the population in HIV-related educational programs, but also strongly underlines the need to modify the medium of delivery of these interventions in order to ensure that they accommodate those with low literacy or the visually impaired (for example through the use of verbal information dissemination rather than signage or written media).

Conclusively, as part of the new 2017-2021 National HIV and AIDS Strategic Framework, the Nigerian Agency for the National Control of AIDS has articulated its goal for 90% of vulnerable populations to adopt HIV risk reduction behaviours by 2021.(62) In light of this, the identification of significant risk groups for low HIV-related knowledge in this study contributes to the evidence-informed targeting of interventions in order to meet this goal.

Significant limitations of this study however include firstly the comprehensiveness and predictiveness of the logistic regression model. As the model correctly classified only 68.1% of cases, care must be taken when interpreting odds ratios and subsequently drawing conclusions regarding risk groups for low HIV-related knowledge based on this model.

Moreover, although women's empowerment has been identified as a relevant risk factor for HIV transmission in Nigeria, this could not be included as a potential predictor of HIV-related knowledge in the current model, as sufficient data on women's empowerment indicators are not available in the male survey. The investigation of women's empowerment as a predictor of HIV-related knowledge would however be relevant, particularly considering the fact that the interaction of wealth inequality and gender inequality has been shown to be a predictor of extramarital and transactional sex among women in Nigeria, thus predisposing them to a higher risk of HIV transmission.(32, 33) It would therefore be relevant to determine the role of HIV-related knowledge under these circumstances, and consequently its potential as a moderator of unsafe sexual behaviours in contexts of wealth and gender inequalities, as well as, ultimately, its value as a factor amenable to improvement for the reduction of HIV transmission in these contexts.

Moreover, in order to determine whether HIV-related knowledge is a significant predictor of actual risk of HIV infection, it would have been of interest to analyse individual HIV positivity in this sample as well, however, individual-level HIV testing data is not available in the 2013 NDHS. As relationships between health-related knowledge and subsequent health-related behaviours have been demonstrated,(63) this study nonetheless provides a valuable evidence base for the targeting and adaptation of HIV-related educational interventions in Nigeria, however, the pertinence of future studies in the Nigerian context could be increased by an examination of the role of HIV-related knowledge as a predictor of actual HIV-related health behaviours and ultimately HIV infection.

Furthermore, the future investigation of wealth inequality as a direct predictor of actual HIV transmission (rather than HIV-related knowledge) in Nigeria is also relevant, given that subgroups of the poor who live in areas that are generally wealthy may be particularly likely to experience increased marginalization, as such areas may be less likely to offer services or programs that are targeted at, accessible to, or affordable for, its poorest residents. Therefore, poorer individuals living in areas of comparative wealth may, as a result of their social and economic exclusion, face significant barriers to accessing information, participating in preventive interventions, or receiving treatment, and therefore ultimately be at higher risk for HIV transmission.

4.6 Conclusion

Despite the limitations of this study in terms of the lack of individual-level HIV infection data, as well as the potential limitations of the accuracy of the model, the study fills a relevant knowledge gap regarding HIV-related knowledge in Nigeria, being the first study to examine in detail the socio-demographic determinants of HIV-related knowledge in the country, and the first to investigate wealth inequality as a significant predictor of HIV-related knowledge. The identification of risk groups for low HIV-related knowledge through this study will allow the more evidence-based design and targeting of HIV education and prevention programs, and the underlining of wealth inequality as a barrier to accessing and acquiring HIV prevention information provides impetus for future studies in the Nigerian context to investigate the role of wealth inequality, rather than solely absolute poverty, as a predictor of actual HIV transmission risk. Ultimately, this will facilitate the improvement of our understanding of the marked heterogeneity in HIV prevalence seen across the country, and consequently the implementation of more effective preventive strategies among the most affected populations.

4.7 Declarations

4.7.1 Author Contributions

LF and SY were responsible for study design. LF conducted the data analysis and was responsible for drafting the manuscript. SY and ME provided input and comments on successive drafts. All authors read and approved the final draft.

4.7.2 Conflicts of Interest

None declared.

4.7.3 Funding

None declared.

4.7.4 Data Sharing Statement

No additional data available.

4.7.5 Acknowledgments

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4.8 Relevant Appendices

- Appendix 4.1 Questions included in computation of HIV-related knowledge scores in Papers 1 and 2
- Appendix 4.2. Comparison of Demographic Characteristics of Respondents With and Without Available Data for Literacy Level (2013 NDHS)

CHAPTER FIVE: PAPER 2

HIV-Related Knowledge in Nigeria: A 2003-2013 Trend Analysis

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5.1 Abstract

Background: Given Nigeria's status as the country with the second highest number of people living with HIV globally, and 9% of the total global burden of HIV being attributable to Nigeria alone in 2013, improving our understanding of the nature of the HIV epidemic in Nigeria is crucial. As HIV-related knowledge may be an important contributor to engagement in preventive behaviours, it is of interest to investigate trends in HIV-related knowledge in Nigeria with the purpose of informing future HIV prevention and education efforts. This study therefore aims to investigate trends in HIV-related knowledge in Nigeria between 2003 and 2013.

Methodology: Data were derived from the 2003-2013 Nigerian Demographic and Health Surveys, and HIV-related knowledge scores were computed based on answers to HIV-related knowledge questions in the surveys. The significance of the difference between HIV-related knowledge across the time points was determined via the Kruskal-Wallis test, and changes in HIV-related knowledge were displayed graphically, stratified by relevant socio-demographic characteristics. ARIMA models were fit to the 2003 to 2013 trend data.

Results: Although there was generally a decrease in HIV-related knowledge across most knowledge domains in 2008, an overall increase was observed between 2003 and 2013. Unfortunately however, this was not the case for knowledge of mother-to-child transmission, which decreased between 2003 and 2013. The disparity in knowledge of HIV risk reduction between states also increased over time.

Conclusion: These findings suggest that although HIV-related knowledge appears to be increasing overall, future HIV prevention and education programs should focus on specific knowledge domains such as mother-to-child transmission, and on specific states in which HIV-related knowledge remains low.

5.2 Background

As of 2015, 3.5 million people were estimated to be living with HIV in Nigeria, and the disease is estimated to have resulted in 180,000 deaths in that year.(4) Given Nigeria's status as the country with the second highest number of people living with HIV globally, and 9% of the total global burden of HIV being attributable to Nigeria alone in 2013,(5) improving our understanding of the nature of the HIV epidemic in Nigeria is crucial.

Previous studies have emphasised that increasing HIV-related knowledge is a critical aspect of HIV prevention, (45, 64, 65) underlining its influence on the likelihood of engagement in preventive behaviours,(63) but few studies have examined trends in HIV-related knowledge in Sub-Saharan Africa, with one study doing so in Uganda,(66) and others in Ethiopia(67) and South Africa.(68) Importantly, despite the fact that low HIV-related knowledge, and consequently lower engagement in preventive behaviours, is considered a relevant factor in the transmission of HIV in Nigeria, HIV-related knowledge levels in the country have not been studied in detail.(13) Although a prior study in Nigeria examines the association of HIV transmission and prevention knowledge indicators with HIV-related stigmatization,(69) trends in these knowledge indicators themselves were not investigated, and these remain to be analysed, particularly in the context of national efforts to improve awareness and knowledge of HIV.

In working towards the millennium development goal of halting and beginning to reverse the spread of HIV/AIDS by 2015, Nigeria launched the National Strategic Plan (NSP) to combat HIV/AIDS. This program ran from 2010 to 2015, and focused on prevention, aiming to reduce the transmission of the disease through the modification of behavioural practices and improving public HIV-related knowledge. (13) Importantly however, despite including the support of research activities and the reduction of gender inequities in its mandate, Nigeria's National Agency for the Control of AIDS (NACA) reports that evidence-based programing and gender-based approaches in the strategy remain to be improved. (13) As such, this study will investigate the trends in HIV-related knowledge between 2003 and 2013, and stratify the investigation of these trends by socio-demographic characteristics such as gender and income, in order to determine whether HIV-related knowledge has increased since the implementation of the NSP, and whether this increase differs among socio-demographic groups. The selection of these socio-demographic factors is based on a recent study by the authors, in which logistic regression analyses indicated that factors including poverty, low literacy, and being female, among other factors, are associated with a higher likelihood of having low HIV-related knowledge.(70)

As prior studies in Sub-Saharan Africa have reported that wealth inequality, rather than absolute wealth or poverty, is a stronger driver of HIV transmission,(2, 3, 25, 26) and a prior study using Nigerian data has found that, particularly among females, high wealth inequality

is associated with lower HIV-related knowledge,(70) the observed trends in HIV-related knowledge over time will also be described with respect to state-level wealth inequality rather than solely absolute wealth. Investigating changes in the levels of HIV-related knowledge prior to and following the implementation of the NSP, and observing differences in these changes across various socio-demographic strata will shed light on whether or not the NSP was effective in increasing general population-level knowledge and understanding of HIV transmission, and in which socio-demographic groups this was most or least successful, in order to inform future national HIV education efforts and more specific targeting of such efforts among priority groups.

5.3 Study Objectives

The purpose of this study was to describe trends in HIV-related knowledge in Nigeria from 2003 to 2013.

5.4 Methods

5.4.1 Data Source:

This study is based on the 2003, 2008, and 2013 Nigerian Demographic and Health Surveys (NDHS),(6, 46, 47) nationally representative surveys of men and women in Nigeria. As the 2013 survey only contained data on respondents aged 15 to 49 years, cases older than 49 years in the 2003 and 2008 datasets were excluded from this analysis, giving total final sample sizes of n= 9713, n=47193, and n=56307 for 2003, 2008, and 2013, respectively. As the survey is based on females in all of the sampled households and males in half of the sampled households (in 2008 and 2013) or one third of the sampled households (in 2003), there is greater representation of females than males in these surveys. The sampling procedure for the NDHS involved a 3-stage (in 2013) or 2-stage (in 2003 and 2008) stratification, in which respondents were first stratified by urban versus rural dwelling, and households were subsequently selected using equal probability sampling. This sampling method was taken into account in the computation of survey weights, applied to ensure the representativeness of the sample with regards to the general population. Data for this study is derived from the individual female and male datasets in each year, merged prior to data analysis.

5.4.2 Variables Measured:

The outcome variable, HIV-related knowledge, was computed as the sum of correct answers to HIV-related awareness and knowledge questions in the NDHS. For questions assessing HIV-related knowledge, answers were recoded as follows: correct answer = 1, incorrect answer = 0, do not know = 0 (see **Appendix 4.1**). For questions assessing HIV-related awareness (questions 1-3, **Appendix 4.1**), aware = 1, unaware = 0. Twelve questions were included in the HIV-related knowledge total score (shown in **Appendix 4.1**), giving a highest possible total score of 12. For a more detailed analysis of different areas of HIV-related knowledge, these 12 questions were then also separated into four knowledge domains (general HIV-related knowledge, knowledge of risk reduction measures, general knowledge of transmission routes, and knowledge of mother-to-child transmission), with a highest possible score of 3 in each category.

Although the main independent variable is time, changes in HIV-related knowledge over time were analysed stratified by several socioeconomic and demographic factors, identified as predictors of HIV-related knowledge in a recent paper.(70) These factors included age, sex, rural or urban residency, literacy level, educational attainment, employment status, ethnicity, religion, absolute wealth, and state-level wealth inequality.

Literacy was recoded from its initial categories into dichotomous categories (literate vs. low literacy level/illiterate/visually impaired), and cases for which a literacy assessment card was unavailable were coded as missing and dropped from subsequent analyses. Absolute wealth was defined using the continuous wealth scores calculated in the NDHS, which are derived from an asset index of household goods (such as the ownership of livestock), and subsequently categorized into quintiles at the national level. State-level wealth inequality was calculated through an additive transformation of the continuous wealth scores to give only positive values,(3) followed by the sorting of transformed scores by state, and the computation of the ratio of the lower over the upper wealth quintile to produce a state-level wealth inequality ratio.

5.4.3 Data Analysis:

As the distributions of scores for all four HIV-related knowledge domains as well as the overall HIV-related knowledge score were non-normal (3SD > mean) in one or more of the three years, analysis of variance (ANOVA) was not suitable, and thus the Kruskal-Wallis test

was applied to determine whether these distributions differed significantly across the three years. The changes in mean scores for each knowledge domain and overall HIV-related knowledge from 2003 to 2013 were then displayed graphically, stratified by the relevant aforementioned socioeconomic and demographic variables. Autoregressive Integrated Moving Average (ARIMA) models were fit to the 2003-2013 trend in HIV-related knowledge for all knowledge domains. Possible predictors were selected for the models based on a prior analysis of socio-demographic determinants of HIV-related knowledge in a forthcoming paper, and were entered into the models individually. The ARIMA models with the most accurate fit (those resulting in the highest R-squared value and lowest mean absolute percentage error (MAPE)) are presented.

5.4.4 Ethics Approval:

The DHS program obtains informed consent from participants prior to data collection, and all data is anonymous, with survey respondents remaining unidentified. Ethics approval for all surveys carried out by the DHS program is granted through the U.S Department of Health and Human Services, and in addition, the Nigerian DHS is conducted according to local Nigerian research ethics requirements. Data for this analysis were accessed via the publicly available DHS datasets, with access granted by the DHS program. As this was a secondary data analysis, further research ethics approval was not required, however, in accordance with DHS regulations, all data extracted from the NDHS for the purpose of this study were handled as confidential and survey respondents remained unidentified. This study conforms to the principles of the Declaration of Helsinki.

5.5 Results

5.5.1 Sample Characteristics:

In the 2003 sample, 36.6% had less than primary education, 48.4% were literate, 58.6% employed, and 64.8% rural-dwelling, whilst in the 2008 sample 30.8% of respondents had less than primary education, 53.6% were literate, 65.6% were employed, and 63.7% resided in rural areas. Lastly, 32.7% of the 2013 sample had less than a primary school education, 52.9% were literate, 66.6% employed, and 57.3% rural-dwelling. Further socio-demographic characteristics are shown in **Table 5.1.**

Table 5.1. Demographic Characteristics of Nigerian Demographic and Health Survey Respondents in 2003, 2008 and 2013

		Year					
		2003		2008		2013	
Demographic Characteristics		**N**	**%**	**N**	**%**	**N**	**%**
Sex	Male	2093	21.6	13808	29.3	17359	30.8
	Female	7620	78.4	33385	70.7	38948	69.2
Age Group (Years)	15-24	4089	42.1	17537	37.2	21088	37.5
	25-34	2950	30.4	15459	32.8	17783	31.6
	35-49	2674	27.5	14197	30.1	17436	31.0
Rural / Urban Residence	Urban	3421	35.2	17150	36.3	24026	42.7
	Rural	6292	64.8	30043	63.7	32281	57.3
Ethnicity	Other	3631	37.4	15008	31.9	19225	34.1
	Fulani	576	5.9	2764	5.9	3518	6.2
	Hausa	2584	26.6	10538	22.4	15417	27.4
	Ibibio	353	3.6	1159	2.5	1261	2.2
	Igbo	1323	13.6	7294	15.5	7967	14.1
	Ijaw	118	1.2	1790	3.8	1097	1.9
	Yoruba	1127	11.6	8479	18.0	7823	13.9
Religion	Other	12	0.1	112	0.2	298	0.5
	Catholic	1307	13.5	5444	11.6	6329	11.2
	Other Christian	3375	34.8	19866	42.3	20102	35.7
	Islam	4910	50.6	20999	44.7	29057	51.6
	Traditionalist	103	1.1	566	1.2	521	0.9
Relationship Status	Never married	2974	30.6	14945	31.7	17704	31.4
	Currently married	6342	65.3	30596	64.8	36552	64.9
	Formerly married	398	4.1	1647	3.5	2051	3.6
Highest Educational Attainment	No education	3555	36.6	14539	30.8	18414	32.7
	Primary	2148	22.1	9327	19.8	9640	17.1
	Secondary	3303	34.0	18374	38.9	22208	39.4
	Higher	707	7.3	4953	10.5	6044	10.7
Literacy Level	Low literacy/ illiterate [a]	4913	51.6	21697	46.4	26354	47.1
	Literate	4615	48.4	25073	53.6	29542	52.9
Employment Status	Unemployed	4011	41.4	16132	34.4	18720	33.4
	Employed	5681	58.6	30793	65.6	37305	66.6
National Wealth Quintile	Lower 20th	1776	18.3	8469	17.9	9994	17.7
	40th	1799	18.5	8566	18.2	10420	18.5

	60th	1905	19.6	8910	18.9	10824	19.2
	80th	1978	20.4	10101	21.4	11827	21.0
	Upper 20th	2255	23.2	11147	23.6	13242	23.5
State-level Wealth	<1.50	449	4.6	3646	7.7	8012	14.2
Inequality Ratio	1.50-1.99	921	9.5	3770	8.0	33742	59.9
	2.00-2.49	754	7.8	9800	20.8	12464	22.1
	2.50-3.00	2021	20.8	10807	22.9	2088	3.7
	3.01-4.00	3097	31.9	9690	20.5	0	0.0
	4.01-5.00	1419	14.6	7448	15.8	0	0.0
	>5.00	1052	10.8	2031	4.3	0	0.0

[a] Includes the visually impaired.

5.5.2 Trends in HIV-Related Knowledge, 2003-2013:

The overall HIV-related knowledge score for the samples [mean (SD)] were 9.18 (1.83), 8.09 (2.80) and 8.62 (2.50) in 2003, 2008, and 2013, respectively. Mean scores for the subdomains of HIV-related knowledge in each year are shown in **Table 5.2**.

Kruskal-Wallis tests indicated that the distribution of HIV-related knowledge scores differed significantly across years for all knowledge domains, as well as for overall HIV-related knowledge (all $p<0.001$).

Table 5.2. Mean HIV-Related Knowledge Scores in the Nigerian Population, 2003-2013.

	Year					
	2003		2008		2013	
HIV-Related Knowledge Score	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
General HIV-Related Knowledge	2.09	0.77	2.37	0.71	2.43	0.68
Mother-to-Child-Transmission	2.69	0.67	1.70	1.31	1.84	1.24
Other Modes of Transmission	1.84	1.05	2.02	1.06	2.22	0.98
HIV Risk Reduction	2.02	0.84	1.99	0.98	2.13	0.95
Total, Overall HIV-Related Knowledge	9.18	1.83	8.09	2.80	8.62	2.50

Across all HIV-related knowledge domains apart from general HIV-related knowledge, scores were generally found to be lower in 2008 than in 2003 or 2013. Furthermore, alarmingly, although knowledge levels for the other knowledge subdomains were higher in 2013 than in 2003, knowledge of mother-to-child transmission (MTCT) dropped significantly in 2013 in comparison to 2003 levels ($p<0.001$, as derived from Kruskal-Wallis analysis).

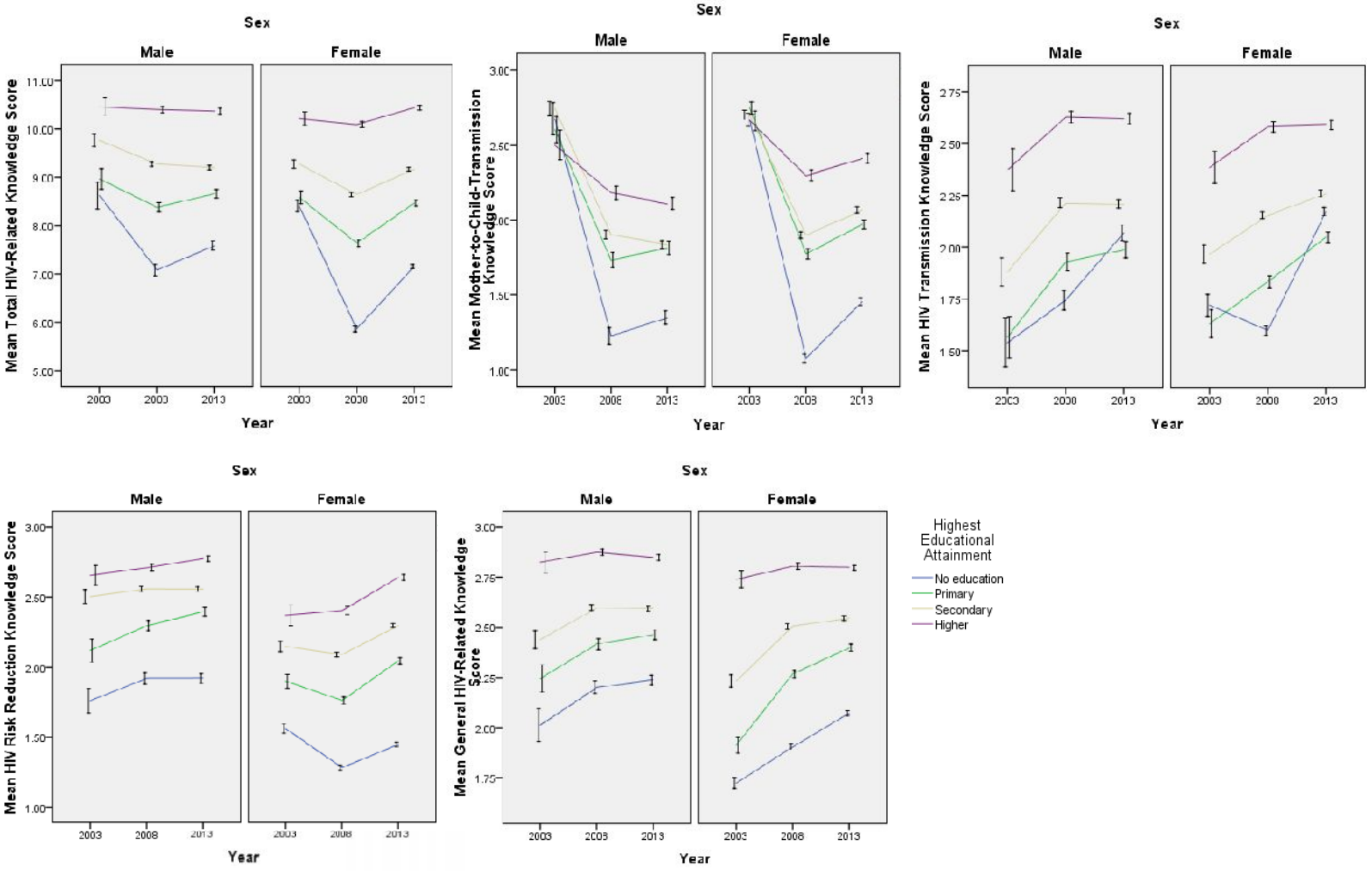
This trend in mean HIV-related knowledge domains over the 2003-2013 period, stratified by various socio-demographic variables, is shown in **Figures 5.1-5.4.**

It is, in addition, interesting to note that in general, across time points, HIV-related knowledge is higher in males than in females for all knowledge domains, except knowledge of mother-to-child transmission (MTCT). Moreover, HIV-related knowledge is higher at each higher level of wealth, as well as being higher for literate compared to illiterate respondents, and these observations remain true over time. Moreover, as seen in **Figure 5.3**, particularly in the risk reduction knowledge panel, although knowledge levels are generally similar among males and females when wealth inequality is low (wealth inequality ratio <1.50), the decrease in risk reduction knowledge is more pronounced among females than among males at higher levels of wealth inequality.

Lastly, mean HIV-related knowledge scores in each state from 2003 to 2013 are shown in **Figure 5.5.** States with relatively low scores across all knowledge domains as of 2013 include states such as Zamfara, Yebbi and Bauchi in the north of the country, whilst states further south, such as Osun and Bayelsa, had higher 2013 HIV-related knowledge scores across most knowledge domains. It is notable that in some knowledge domains, the disparity between HIV-related knowledge between states is large. For example, the mean score for risk reduction knowledge in 2013 ranges from 2.70 in Osun to only 0.98 in Zamfara, and this disparity has grown larger over time, being greater in 2013 than in the previous years.

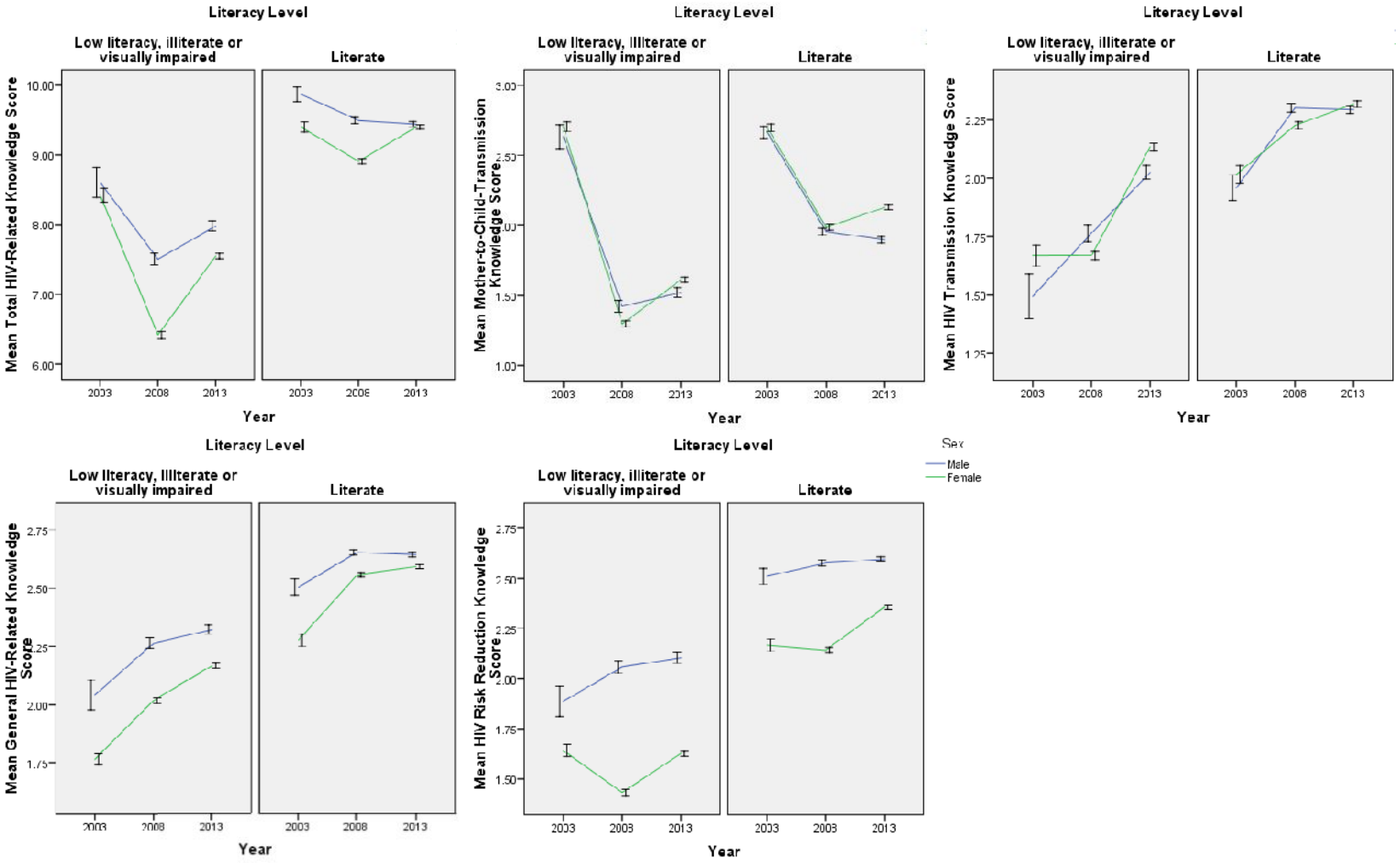
In time series analyses of total HIV-related knowledge, an ARIMA model with the proportion of literate respondents in each year as a single predictor yielded the highest R-squared value (0.857), as was also the case for the MTCT and risk reduction knowledge domains (R-squared values 1.000 and 0.572, respectively). For knowledge of HIV transmission, the best model fit was obtained with wealth inequality as single predictor (R-squared 0.999), whilst for general HIV-related knowledge, the proportion of rural-dwelling respondents in each year as predictor provided the best fit (R-squared 0.709). The ARIMA models for total HIV-related knowledge and each knowledge domain over the 2003 to 2013 time period are shown in **Figure 5.6**. Forecasts could not be generated by any of the models due to data limitations.

Figure 5.1. HIV-Related Knowledge in Nigeria by Sex and Educational Attainment, 2003-2013.



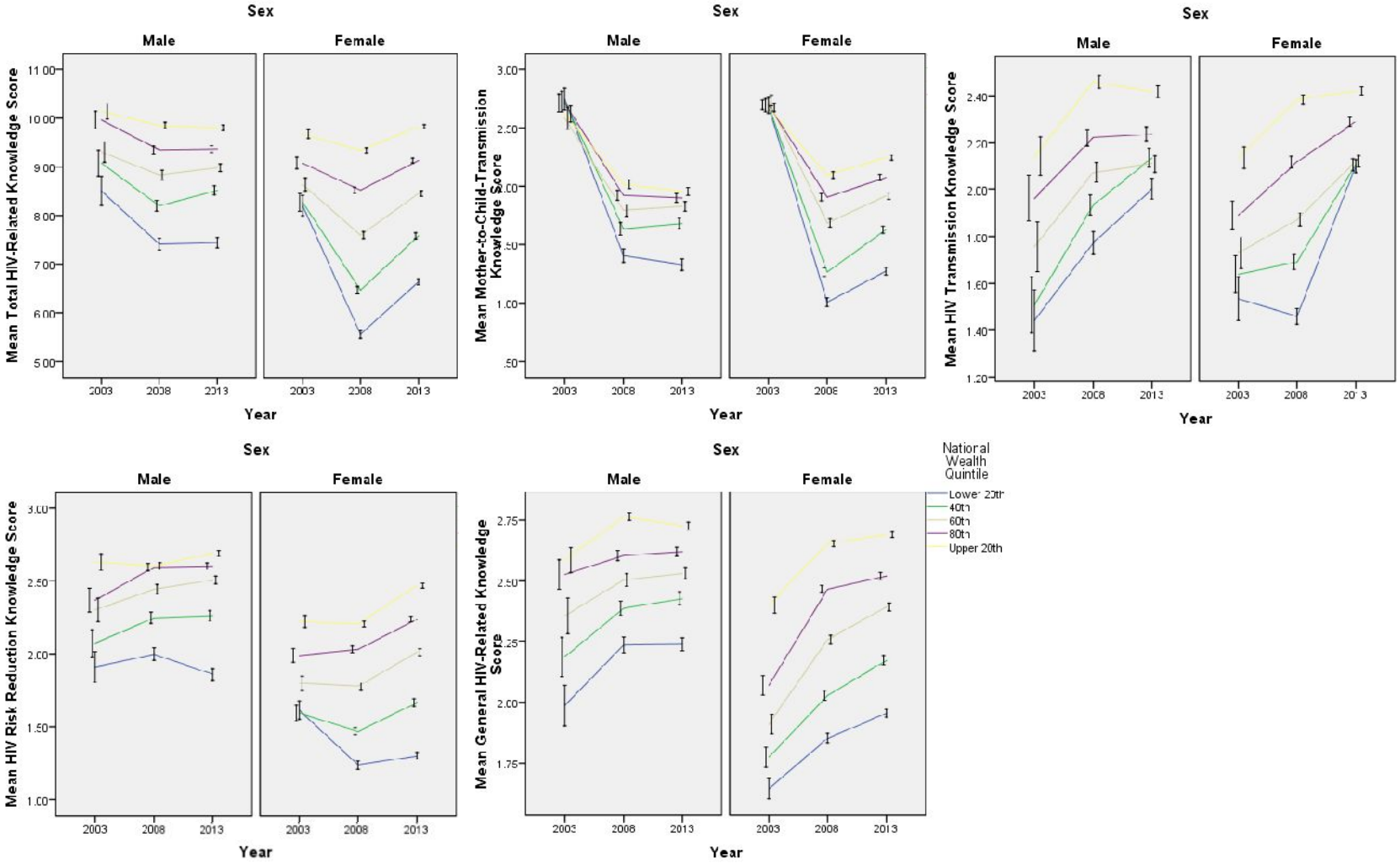
Cases weighted by: $\frac{\text{NDHS individual sample weight}}{1{,}000{,}000}$ as per DHS guidelines. Error bars: 95% CI.

Figure 5.2. HIV-Related Knowledge in Nigeria by Sex and Literacy Level, 2003-2013.



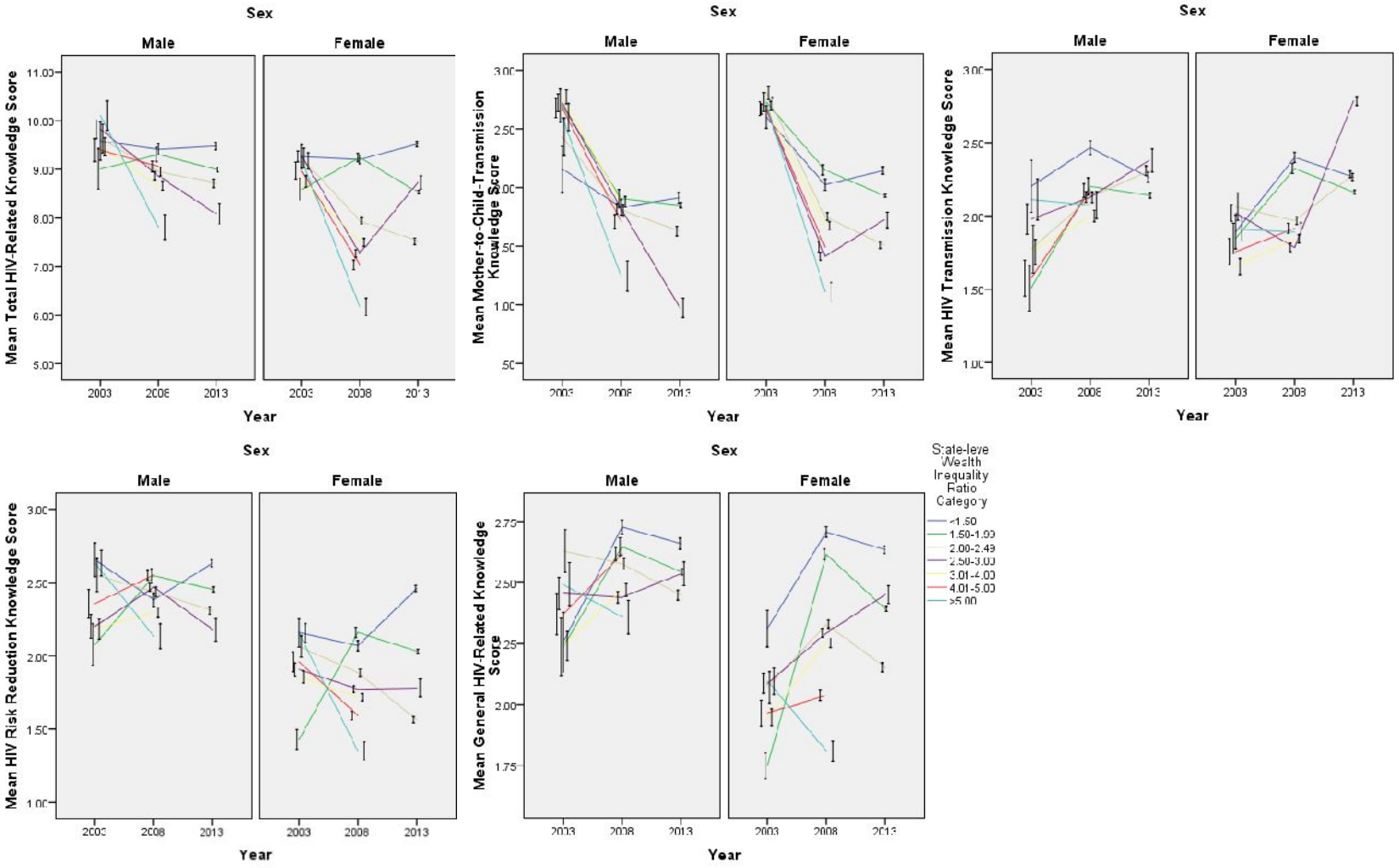
Cases weighted by: $\frac{\text{NDHS individual sample weight}}{1{,}000{,}000}$ as per DHS guidelines. Error bars: 95% CI.

Figure 5.3. HIV-Related Knowledge in Nigeria by Sex and National Wealth Quintile, 2003-2013.



Cases weighted by: $\frac{\text{NDHS individual sample weight}}{1{,}000{,}000}$ as per DHS guidelines. Error bars: 95% CI.

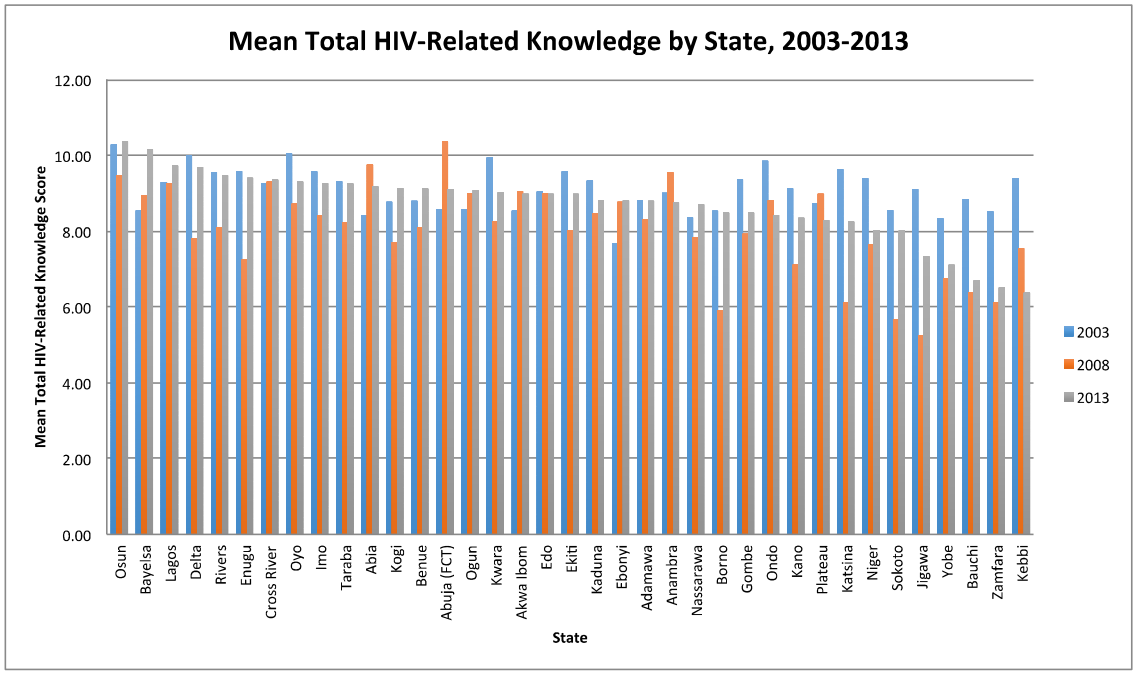
Figure 5.4. HIV-Related Knowledge in Nigeria by Sex and Wealth Inequality Ratio Category, 2003-2013.

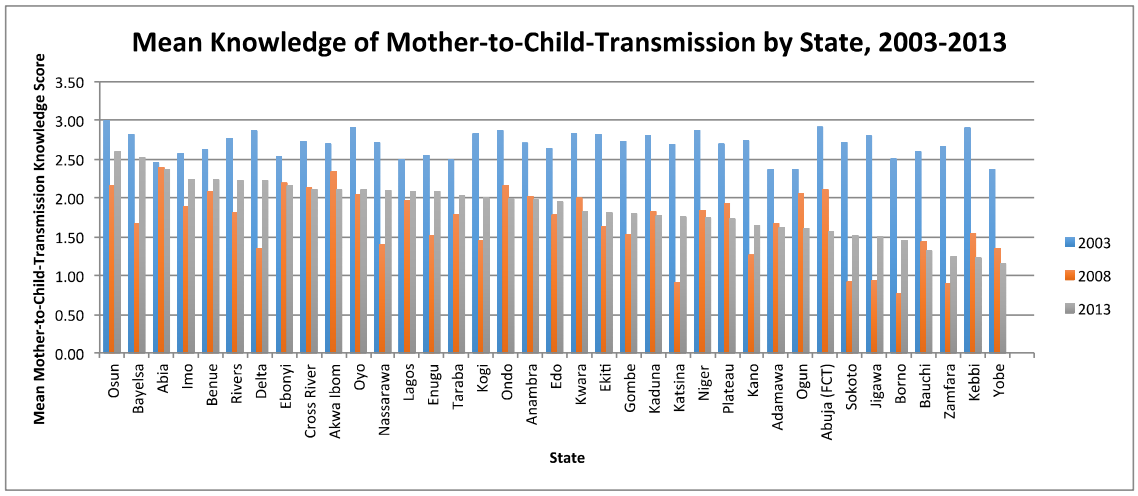


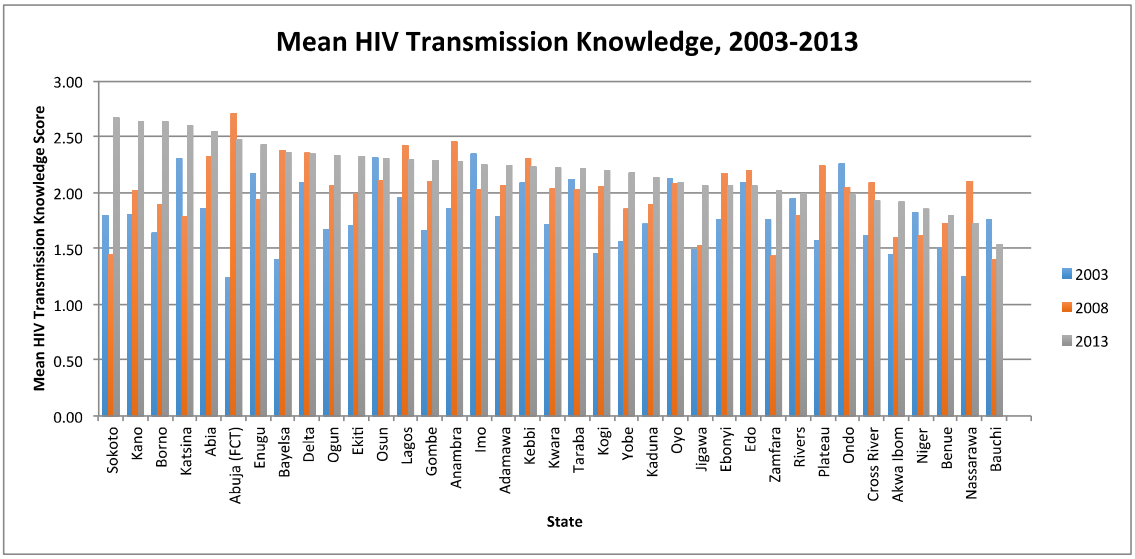
Cases weighted by: $\frac{\text{NDHS individual sample weight}}{1{,}000{,}000}$ as per DHS guidelines. Error bars: 95% CI.

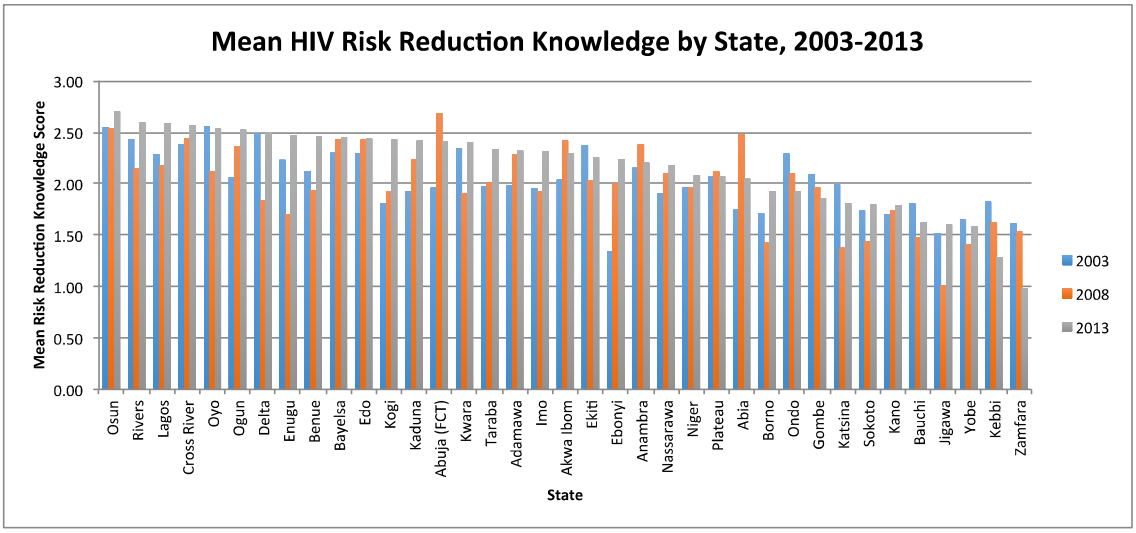
Figure 5.5. HIV-Related Knowledge by State [a] in Nigeria, 2003-2013.

[a] States are in order of highest to lowest knowledge score for 2013






Mean HIV Transmission Knowledge, 2003-2013
Mean HIV Transmission Knowledge Score
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Sokoto Kano Borno Katsina Abia Abuja (FCT) Enugu Bayelsa Delta Ogun Ekiti Osun Lagos Gombe Anambra Imo Adamawa Kebbi Kwara Taraba Kogi Yobe Kaduna Oyo Jigawa Ebonyi Edo Zamfara Rivers Plateau Ondo Cross River Akwa Ibom Niger Benue Nassarawa Bauchi
State
2003
2008
2013


Mean HIV Risk Reduction Knowledge by State, 2003-2013
Mean Risk Reduction Knowledge Score
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Osun Rivers Lagos Cross River Oyo Ogun Delta Enugu Benue Bayelsa Edo Kogi Kaduna Abuja (FCT) Kwara Taraba Adamawa Imo Akwa Ibom Ekiti Ebonyi Anambra Nassarawa Niger Plateau Abia Borno Ondo Gombe Katsina Sokoto Kano Bauchi Jigawa Yobe Kebbi Zamfara
State
2003
2008
2013

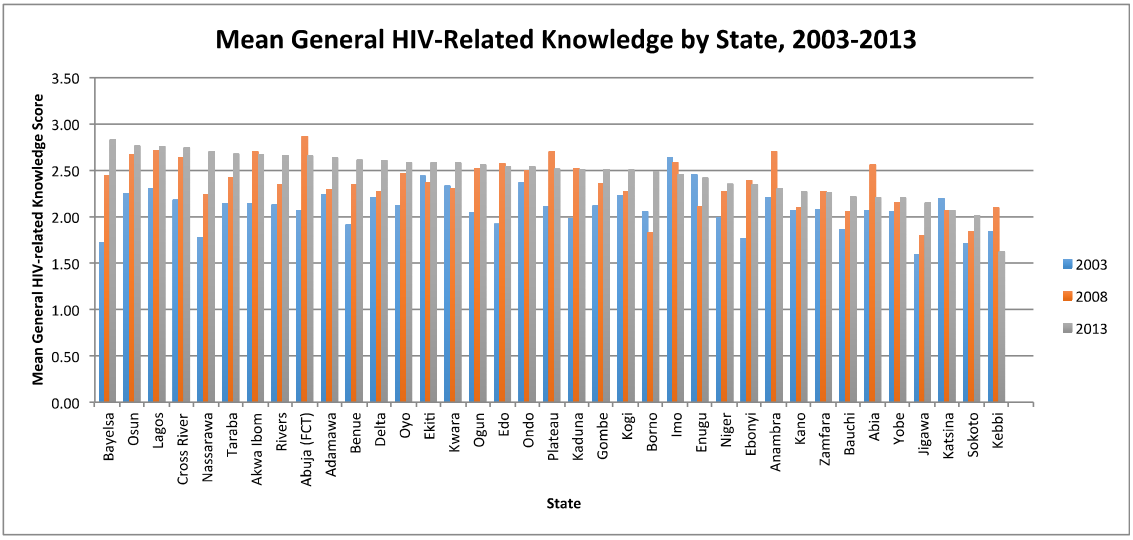
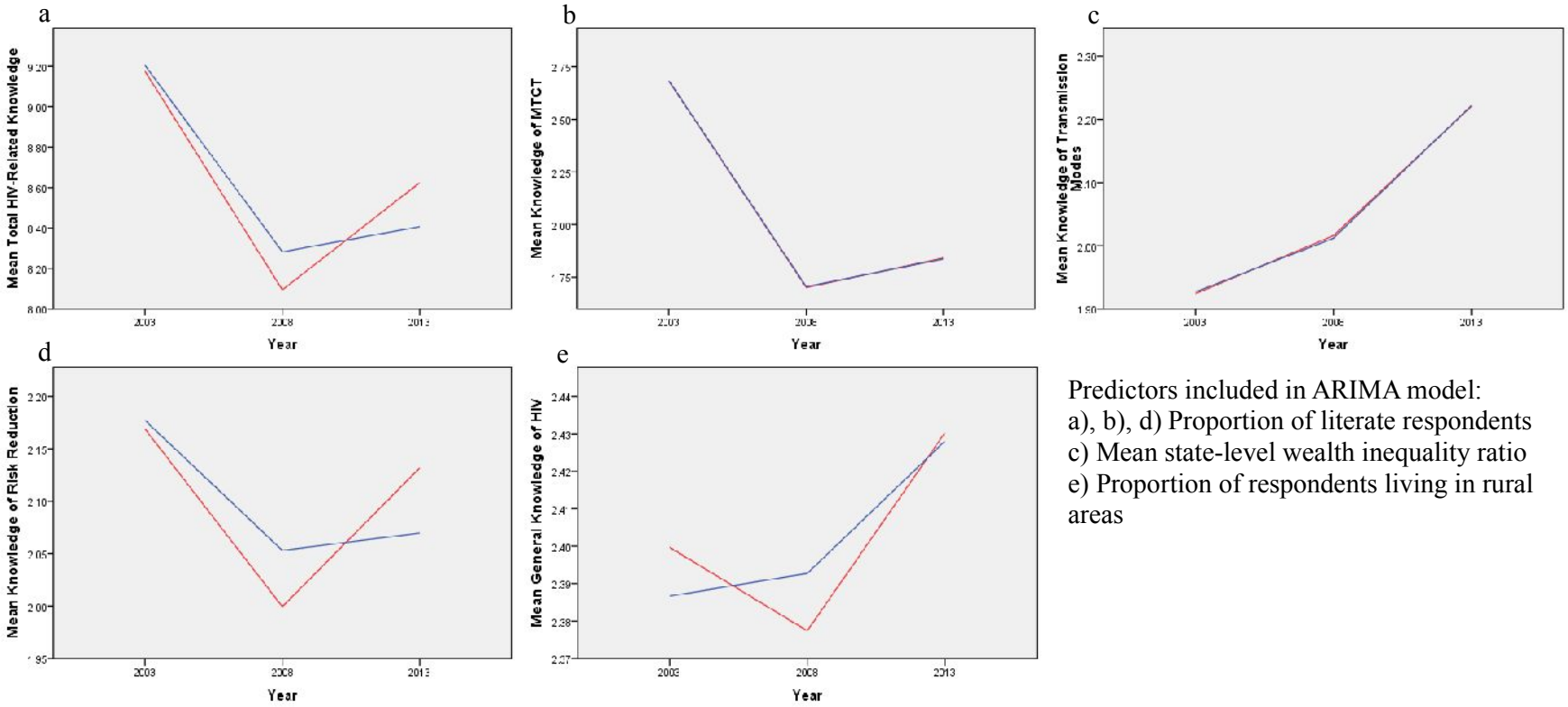

Mean General HIV-Related Knowledge by State, 2003-2013
Mean General HIV-related Knowledge Score
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Bayelsa Osun Lagos Cross River Nassarawa Taraba Akwa Ibom Rivers Abuja (FCT) Adamawa Benue Delta Oyo Ekiti Kwara Ogun Edo Ondo Plateau Kaduna Gombe Kogi Borno Imo Enugu Niger Ebonyi Anambra Kano Zamfara Bauchi Abia Yobe Jigawa Katsina Sokoto Kebbi
State
2003
2008
2013

Figure 5.6. 2003-2013 Time Series Analysis: ARIMA Models for Total HIV-related Knowledge and Knowledge Subdomains in the Nigerian Population



Predictors included in ARIMA model:
a), b), d) Proportion of literate respondents
c) Mean state-level wealth inequality ratio
e) Proportion of respondents living in rural areas

5.6 Discussion

When considering the implications of an analysis of trends in HIV-related knowledge, it is relevant to note at the outset that several Sub-Saharan African studies have reported the effectiveness of behaviour change interventions regarding HIV risk reduction and prevention measures.(71-73) This underlines firstly that interventions improving HIV-related knowledge, when delivered along with behaviour change elements, are associated with a greater likelihood of adoption of appropriate preventive behaviours, and in turn therefore a reduced risk of HIV transmission,(73) and secondly that HIV-related knowledge is a modifiable factor that can and should be targeted through intervention, as part of efforts to prevent further HIV transmission. Regarding the socio-demographic determinants of HIV-related knowledge in Nigeria, a recent paper has shown that factors including poverty, unemployment, low literacy, rural residence, sex, and wealth inequality are significant predictors of HIV-related knowledge in the country.(70) With this in mind, the implications of the current trend analysis in the Nigerian context are discussed.

The low level of HIV-related knowledge seen in 2008 in the current analysis may be explained in part by the fact that HIV-related knowledge in Nigeria may have been low prior to the launching of the National Strategic Plan to combat HIV, which was initiated in 2010. The subsequent rise in 2013 suggests that the plan may have to some extent been effective in increasing overall HIV-related knowledge at the national level, however, due to the limited amount of data, the influence of other societal dynamics and events on this trend remains to be better understood.

Despite this decrease observed in most knowledge domains in 2008, an overall increase is seen from 2003 to 2013 in all knowledge domains except knowledge of mother-to-child transmission, which was significantly lower in 2013 than in 2003. This is particularly alarming given the substantial contribution of MTCT to the continuation of the Nigerian HIV epidemic, with a MTCT prevalence rate of 27.3% in 2014.(13) This suggests that future national programs with an HIV prevention and education mandate should place an increased focus on the prevention of MTCT. Specific recommendations regarding MTCT prevention based on the findings of the current study include that educational interventions emphasizing safe infant feeding practices and encouraging antenatal and postnatal care seeking should be targeted at expectant mothers and females of childbearing age, in particular those who are HIV positive or whose serostatus is unknown. In addition, as mother-to-child transmission knowledge is the only knowledge area in which males scored lower than women, it may be of interest to also include mother-to-child transmission prevention content in HIV education efforts targeted at males. Given that

males may often be the primary household decision-makers, they may be more likely to support their partners in seeking maternal care or in making alternative infant feeding choices if adequately informed of the risks of mother-to-child transmission.

The overall increase in the other HIV-related knowledge domains over time seen in our analysis however aligns with the findings of studies that have examined trends in HIV-related knowledge in other sub-Saharan African countries. The aforementioned study in Ethiopia for example reports an increase in HIV-related knowledge between 2005 and 2011.(67) As knowledge levels in the Ethiopian study were based on only 3 knowledge indicators, one being having heard of HIV, and two relating to risk reduction measures, these results are comparable to the upward trend in the general knowledge and HIV risk reduction domains observed in the current study.

Importantly, although the trends in HIV-related knowledge are similar across socio-demographic strata, there are marked disparities in the levels of knowledge between strata. For example, females generally have lower HIV-related knowledge across most knowledge domains in comparison to males, and those in higher wealth quintiles have higher mean HIV-related knowledge levels than those in lower wealth quintiles. This, as well as the disparities seen in levels of HIV-related knowledge among males compared to females at each level of wealth, and in particular the fact that mean risk reduction knowledge is similar among males and females at low wealth inequality, but is much lower in females than in males in states with higher wealth inequality ratios, suggests that future HIV awareness and education campaigns should be targeted at the most marginalized, particularly those experiencing the confluence of gender and wealth inequalities.

Moreover, the fact that disparities in HIV-related knowledge between literate and illiterate respondents persist from 2003 to 2013 across all knowledge domains suggests an urgent need for the tailoring of future national HIV education programs to the needs of those to whom complex or text-based information is less accessible. This should include the use of non-written media (for example diagrams or pictograms) for the dissemination of HIV-related information, including transmission mechanisms and prevention measures.

Furthermore, the results of this analysis regarding the observation of growing disparities in certain domains of HIV-related knowledge between states suggest that increased focus should be devoted to improving HIV-related knowledge in these specific states in which it is currently low, such as in

Zamfara, Kebbi, and Bauchi. In particular, efforts to improve HIV-related knowledge in these states should focus on the specific knowledge subdomains that are currently most poorly understood.

Regarding the trend analysis using ARIMA modelling, the fact that the proportion of literate respondents as a predictor provided the best fit model for total HIV-related knowledge, risk reduction knowledge, and knowledge of mother-to-child transmission suggests that at the national level, improvements in literacy over time may in part explain and facilitate improvements in HIV-related knowledge. Consequently, this indicates that not only should efforts be made to ensure that HIV education campaigns are more accessible to individuals with low literacy levels, but also that investments into national education and literacy in general will equip individuals with a greater capacity to acquire, understand, and use HIV-related information.

Moreover, the finding that knowledge of HIV transmission in Nigeria was best approximated in the ARIMA model using the mean state-level wealth inequality ratio as the single predictor is of particular interest in light of recent studies on the social determinants of HIV transmission indicating that, in Sub-Saharan Africa, wealth inequality may be a more significant predictor of HIV transmission than absolute poverty or wealth.(2, 3, 25, 26) Additionally, in Nigeria specifically, a recent study investigating wealth inequality as a predictor of HIV-related knowledge(70) indicated that under circumstances of inequality, females in particular are at higher risk of low HIV-related knowledge. The observation that the trend in knowledge of HIV transmission to some extent follows the trend in state-level wealth inequality therefore underlines that under circumstances of inequality, individuals experience both greater barriers to accessing HIV-related health information, as well as greater barriers to the actual application of this information through the adoption of preventive or care-seeking behaviours. Apart from indicating that, particularly in a country as socioeconomically heterogeneous as Nigeria, HIV prevention education should be especially targeted at areas of high wealth inequality, the observed HIV transmission knowledge and wealth inequality trends also suggest that efforts towards reducing wealth disparities in Nigeria could address an important driver of HIV transmission in the country, and consequently substantially reduce future transmission. More specifically, as the current study shows a more pronounced decrease in risk reduction knowledge among females than among males at higher levels of wealth inequality, females living in areas of high wealth inequality should be particularly prioritized for HIV risk reduction interventions. This is particularly relevant given that circumstances of wealth inequality have been shown to be associated with an increase in high HIV risk activities, such as engagement in informal transactional sex. (32, 33)

The limitations of this study include, firstly, the limited number of time points in this analysis, which limited the time series analysis as it precluded the production of trend forecasts from the ARIMA models, therefore limiting conclusions regarding future HIV-related knowledge levels in the country. In addition, the small number of time points between 2003 and 2013 limits the level of detail in our understanding of the trends in HIV-related knowledge over time in the Nigerian context, making it difficult to interpret what these knowledge levels suggest regarding the effectiveness of HIV awareness and education campaigns implemented over the years, or to determine which other events or dynamics may be contributing to the observed trends in knowledge levels.

In addition, the fact that NDHS data is not longitudinal – i.e. not collected from the same individuals over the multiple time points – means that longitudinal data analysis methods are not applicable, and conclusions from this analysis are thus unable to take into account how individual-level changes in absolute wealth, wealth inequality, educational attainment or other socio-economic indicators influence changes in individual-level HIV-related knowledge over time.

It should also be noted that as the DHS sampling procedure includes women in all sampled households and the corresponding men in only a subset of the households from the original female sample, there is a greater representation of women than men in all survey years, however, the effects of this are taken into account through the application of individual sample weights (as provided in the DHS) to the male and female datasets.

Lastly, although health-related knowledge has been shown to lead to favourable health behaviours and engagement in preventive measures and can therefore be considered a relevant factor influencing potential HIV infection risk, the lack of individual HIV serostatus information in the NDHS limits our ability to corroborate the contribution of low HIV-related knowledge to HIV transmission risk. Consequently, the conclusions drawn from an analysis of HIV-related knowledge are of limited value in terms of their direct translation into the evidence-based targeting of HIV preventive interventions among high-risk groups. Future research in Nigeria could therefore focus on the collection of individual-level HIV serostatus data for the determination of whether HIV-related knowledge is a valuable predictor of HIV transmission risk. Moreover, more detailed evaluations of national HIV education and prevention programs in terms of their effectiveness in disseminating HIV preventive

information to vulnerable groups, improving HIV-related knowledge, and ultimately leading to preventive behaviours are needed.

5.7 Conclusion

Overall, through the identification of states, population subgroups and knowledge domains (such as knowledge of MTCT) in which HIV-related knowledge levels have been low or decreasing over time, the understanding of recent trends in HIV-related knowledge as investigated in this paper provides insight for the evidence-based design and targeting of further HIV education efforts. In light of the current study's findings, we suggest several specific strategies for HIV-related knowledge improvement in Nigeria, relating to both the content and method of dissemination of HIV education interventions. Taking continued steps towards improving HIV-related knowledge in Nigeria is particularly relevant in light of the fact that the aforementioned study on attitudes towards HIV in Nigeria demonstrated that individuals with greater understanding of HIV transmission were also less likely to have negative or stigmatizing attitudes towards people living with HIV.(69) This indicates that appropriate HIV education and subsequent improvements in HIV-related knowledge are crucial to reducing the social stigmatization of the disease, which consequently will contribute to increasing at-risk individual's propensity and ability to seek preventive services, as well as facilitating easier access to treatment and strengthening social support for HIV-positive individuals. In addition however, as a prior Sub-Saharan African study has noted discrepancies between HIV awareness and the adoption of protective behaviours,(74) it will be crucial that future HIV education efforts also incorporate elements of behaviour change interventions, in order to maximize their likelihood of resulting in actual increases in preventive behaviours.

5.8 Declarations

5.8.1 Ethics approval and consent to participate

The DHS Program collects and manages data in accordance with the research ethics requirements of the U.S Department of Health and Human Services, ensuring that participants provide informed consent and that the data remain anonymous. As this was a secondary analysis of DHS data, no further ethics approval was required. Data used in this study was treated as confidential as per DHS requirements, and respondents remained unidentified.

5.8.2 Consent for publication

Not applicable.

5.8.3 Availability of data and material

The data that support the findings of this study are available from the DHS Program, but restrictions apply to the availability of these data, which were used with access granted by the DHS Program.

5.8.4 Competing interests

The authors declare that they have no competing interests.

5.8.5 Funding

None to declare.

5.8.6 Authors' contributions

LF and SY were responsible for study design. LF conducted the data analysis and was responsible for drafting the manuscript. SY and ME provided input and comments on successive drafts. All authors read and approved the final draft.

5.8.7 Acknowledgements

The authors would like to acknowledge the DHS Program for the provision of datasets.

5.9 Relevant Appendices

- Appendix 4.1 Questions included in computation of HIV-related knowledge scores in Papers 1 and 2
- Appendix 4.2. Comparison of Demographic Characteristics of Respondents With and Without Available Data for Literacy Level (2013 NDHS)
- Appendix 5.1. Comparison of Demographic Characteristics of Respondents With and Without Available Data for Literacy Level (2003 and 2008 NDHS)

CHAPTER SIX: PAPER 3

The Effect of HIV Educational Interventions on HIV-Related Knowledge, Condom Use, and HIV Incidence in Sub-Saharan Africa and the African Diaspora: A Systematic Review and Meta-analysis

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6.1 Abstract

Introduction: As high stigmatization of HIV and relatively low knowledge of HIV transmission and prevention measures persist in Sub-Saharan Africa, the improvement of HIV-related knowledge, and the evaluation of which types of interventions are most effective in this regard, is an important aspect of further prevention efforts. In addition, it is of interest to assess whether improvements in HIV-related knowledge may actually lead to increased engagement in preventive behaviours and ultimately lower HIV transmission. This study therefore aims to systematically review and meta-analyse the evidence for the effect of HIV-related knowledge interventions on 1) the improvement of HIV-related knowledge, 2) subsequent risk reduction behaviour (condom use), 3) lower incidence of HIV infection.

Methods: A literature search was conducted using the Embase and Medline databases, returning 746 studies after duplicate removal. Following abstract and full-text screening, 48 studies were ultimately included in the final review. Meta-analyses were conducted in R, using random-effects models, for the HIV-related knowledge, condom use, and HIV incidence outcomes, where sufficient data were available.

Results: Interventions assessed in the reviewed studies varied, including computer-based interventions, mass media campaigns, and peer education interventions. The interventions were generally found to be effective at improving HIV-related knowledge in the target population, with 10 studies reporting improved knowledge of risk reduction through condom use in the intervention group (out of 12 studies reporting data for this outcome), with 6 reporting these differences as significant ($p<0.05$). Regarding knowledge of transmission routes, studies assessing peer education interventions often reported significant improvements in the intervention group. Meta-analysis results showed significantly higher odds among the intervention groups of correct knowledge of sexual transmission of HIV (OR: 5.86, 95%CI: 2.65-12.97, $p<0.001$) and transmission through sharps (OR: 4.35, 95%CI=3.21-5.90, $p<0.001$), but non-significantly lower odds of HIV infection (OR: 0.97, 95%CI: 0.66-1.41, $p=0.854$).

Conclusion: Peer-education-based interventions appear to be particularly effective in facilitating the uptake of HIV-related knowledge, particularly pertaining to transmission routes. There is some evidence that improved knowledge of HIV transmission and prevention facilitates increased subsequent engagement in preventive measures, although this requires further exploration.

PROSPERO Number: CRD42018090600

6.2 Introduction

Given that Sub-Saharan Africa accounts for more than 70% of worldwide HIV cases,(75) investigating effective approaches to HIV prevention in the area remains urgent. As high stigmatization of the disease and relatively low knowledge of HIV transmission and prevention measures in the region persist,(70) the improvement of HIV-related knowledge is an important aspect of further prevention efforts,(45, 64, 65) as an understanding of one's risk of contracting or transmitting the disease, as well as an understanding of effective preventive measures has the potential to increase engagement in such measures,(63) and in turn reduce future transmission.

Thus far, efforts towards improving HIV-related knowledge in Sub-Saharan Africa or among the Sub-Saharan African diaspora have encompassed a wide variety of intervention types and methods of disseminating HIV-related information, such as peer education,(76-78) game-based education,(79) skill-building interventions,(80-82) mass media campaigns,(83) and, at later times, text messaging (84) as well as computer-based intervention programs.(85, 86) Many such interventions have drawn on various theoretical frameworks, such as social cognitive theory,(77, 87-90) the theory of planned behaviour,(82, 91) and the theory of reasoned action.(92, 93) Recognizing the significant social determinants of the disease, including in particular the roles of gender inequality and female disempowerment in the continued transmission of HIV, educational interventions focusing on HIV prevention have often also been designed with reference to social and gender-inequity-based theories such as the theory of gender and power,(86, 89, 94) social norms theory,(95) and the social constructivist theory of gender.(96) Moreover, interventions based on theories of behaviour change have also been commonly used in interventions aiming to improve HIV-related knowledge, as it has been found that HIV education interventions are associated with a greater likelihood of subsequent adoption of preventive behaviours when implemented in combination with behaviour change elements.(73)

Therefore, although a number of studies in Sub-Saharan Africa have reported on a wide variety of different types of HIV-related knowledge interventions, their effectiveness in the Sub-Saharan population has not yet been systematically compared. Moreover, given that specific socio-demographic risk groups for low HIV-related knowledge have been identified in previous studies, such as a recent study investigating socio-demographic predictors of HIV-related knowledge in Nigeria, (70) it is of interest to examine whether certain interventions are particularly effective among specific strata of the population. This information will aid the further design or adaptation of interventions aimed at

improving HIV-related knowledge in the region, and will allow more targeted resource-allocation to the types of interventions or methods of dissemination that have been found to be most effective.

Lastly, as a number of studies have assessed HIV-related knowledge in various countries across sub-Saharan Africa and South Asia, but many of these did not examine whether higher HIV-related knowledge is actually associated with a lower likelihood of HIV infection, (44, 65, 70) this review will serve as a synthesis of evidence regarding the extent to which improvements in HIV-related knowledge actually lead to increased engagement in preventive behaviours, and subsequently a lower likelihood of HIV infection.

This study will therefore systematically review and meta-analyse the evidence for the influence of HIV-related knowledge interventions on 1) the improvement of HIV-related knowledge, 2) subsequent adoption of risk reduction behaviour (condom use), and 3) incidence of HIV infection.

6.3 Methods

6.3.1 Search Strategy and Study Registration

A literature search of the Embase and Medline databases was conducted in November 2017, using the search term outlined in detail in **Appendix 6.1**. The conduct of this systematic review is reported according to the PRISMA reporting guidelines for systematic reviews and meta-analyses, (48) and the study protocol is registered on the PROSPERO database, available here.

6.3.2 Eligibility Criteria

Eligibility for inclusion in the review were primary, original research studies published in French or English, reporting on the implementation of a HIV-related knowledge intervention in Sub-Saharan Africa or among the African Diaspora. HIV-related knowledge interventions included any interventions that aimed at improving any aspect of HIV-related knowledge, which could include, for example, knowledge of HIV prevention or transmission, or HIV risk reduction interventions. Excluded studies were those not taking place in Sub-Saharan Africa or among the African diaspora, qualitative studies, those not administering an intervention or program aimed at improving HIV-related knowledge (e.g. cross-sectional studies on HIV-related knowledge, general sexual health interventions not specific to HIV, or assessments of knowledge of HIV status only), or those targeting HIV educational interventions at healthcare providers. Also excluded were conference abstracts, editorials, commentaries, study protocols, news articles, and secondary analyses (e.g. reviews or meta-analyses).

6.3.3 Study Selection

Abstracts were screened according to the aforementioned criteria, and full-texts were retrieved for eligible studies. At full-text review, in addition to the abovementioned criteria, studies were excluded if they did not report quantitative data on at least one of the following outcomes of interest: a) changes in HIV-related knowledge (see **Table 6.1.** for included knowledge questions), b) adoption of preventive measures (condom use) or c) HIV incidence. Note that regarding preventive behaviours, only reported condom use was considered an outcome of interest, whilst mere *intention* to do so was not. Studies that did not provide the following for at least one of the outcomes of interest were also excluded: a) pre- and post-intervention data, or b) control group vs. intervention group data. Lastly, if studies included mixed populations (i.e. did not take place in Sub-Saharan Africa and not all of the study population was part of the African diaspora), and results were not stratified by ethnicity, studies were excluded if less than 80% of study subjects were not reported as being of African descent.

6.3.4 Data Collection and Risk of Bias Assessment

The Covidence systematic review management platform (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia) was used for study de-duplication and screening. Data extraction was carried out in Microsoft Excel (Version 14.5.5). Risk of bias for RCTs and non-RCTs was assessed using the 9-item Cochrane Risk of Bias Tool (49, 50), and risk of bias in uncontrolled (e.g. one-arm pre-post studies) was assessed based on the Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control. (51) These tools assess the methodological quality of studies based on criteria such as the random allocation of participants to control or intervention groups, blinding of participants and outcome assessors, cross-contamination of study groups, attrition bias, and bias in outcome reporting.

6.3.5 Data Analysis

For the primary outcome of interest, HIV-related knowledge, data relating to two domains of HIV-related knowledge were extracted: 1) knowledge of HIV risk reduction through condom use 2) knowledge of modes of transmission (through blood and sexual contact). The specific questions for which data were extracted are shown in **Table 6.1**. Data were extracted either as continuous data, in the form of mean knowledge scores, or as categorical data, in the form of proportions of respondents providing correct answers. If studies reported proportions for incorrect answers, the data was transformed to reflect the proportion with correct answers, in order to maintain continuity of outcome reporting across studies. Where it was unclear whether the study was reporting negative or affirmative

answers for a question, the outcome in question was not extracted for this study. Similarly, if multiple knowledge points were combined in a single question (e.g. HIV can be contracted through sexual intercourse and through the sharing of needles), data for this question was not extracted.

Secondary outcomes considered in this review were condom use and HIV incidence. Condom use was measured as defined by the study (e.g. proportion always using condoms, proportion using condoms at last sex, or over a specified time period).

For categorical data (e.g. proportion of participants having correct knowledge) meta-analyses were conducted in cases where more than 2 studies reported data for an outcome and provided sufficient information for the calculation of odds ratios. Continuous data, such as mean condom use, are meta-analysed using the mean difference as the effect size measure. Where possible, analyses were grouped by intervention type. All meta-analyses were carried out in R (specifically the metafor package) (58), using a random-effects model, as the true effect size was expected to vary between studies, given the different locations and target populations of the included studies. (Note that for random effects models, inverse-variance-based weighting is employed, according to $w_i = 1/(\tau^2 + v_i)$, where τ^2 is the between-study variance).

Table 6.1. HIV-related knowledge questions considered in this review

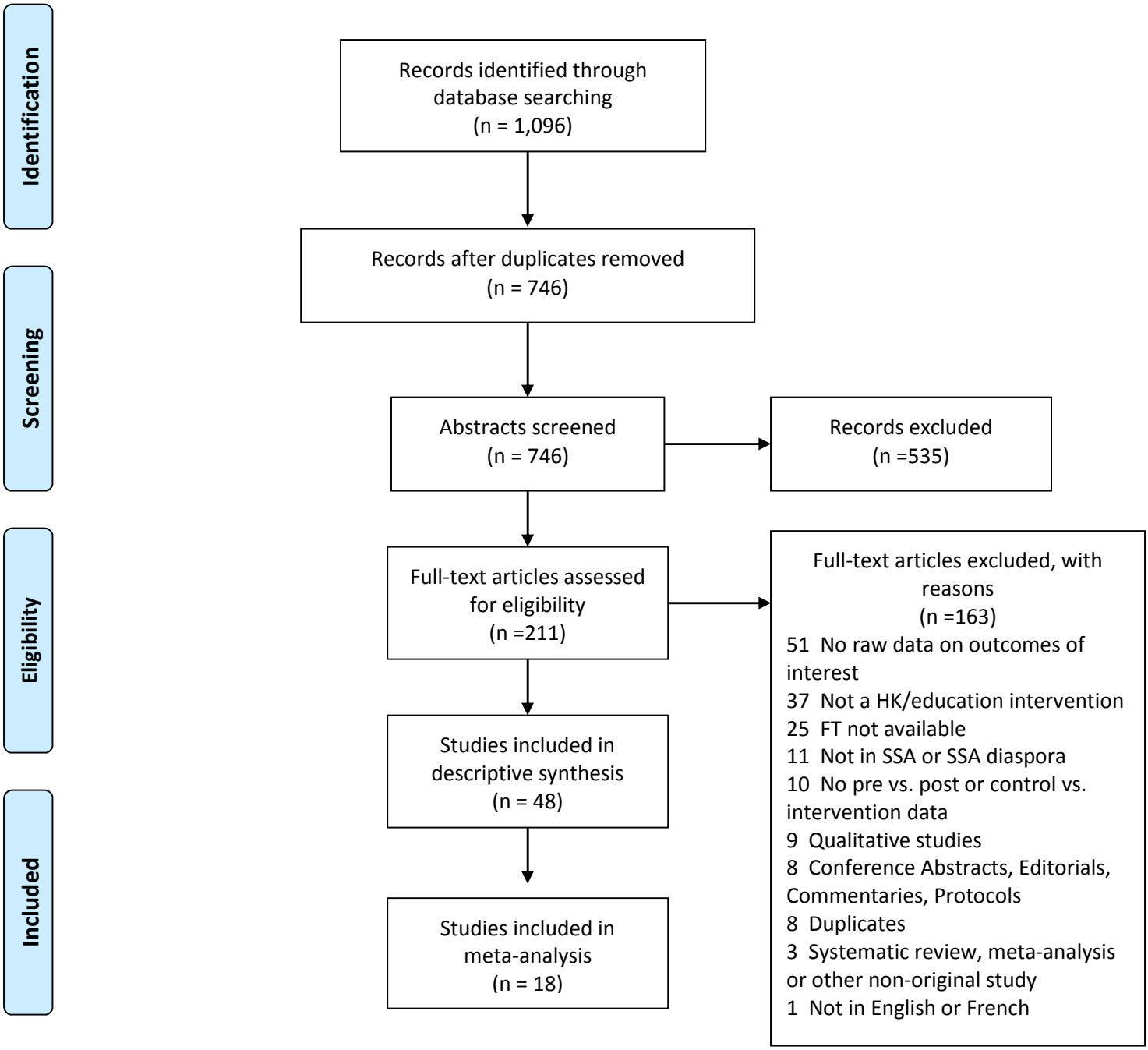
Knowledge Category	Question (correct answer)
Risk Reduction	Using condoms correctly can reduce one's risk of HIV infection (yes)
Transmission Modes	HIV can be transmitted by sexual activity (including oral, anal and genital sex) (yes)
	HIV can be transmitted through contact with an infected individual's blood (yes)
	HIV can be transmitted through sharing sharp objects such as needles with infected individuals (yes)

6.4 Results

6.4.1 Search Results

The literature search (see appendix for search term) returned 1096 studies, with 746 remaining after duplicate removal. 535 studies were excluded after abstract screening, and thus 211 full articles were screened. Following 163 exclusions at full-text level (mainly due to not reporting raw data on the outcomes of interest (n=51), or not reporting on a HIV-related knowledge intervention (n=37)) 48 studies were included in the final review. **Figure 6.1** shows the study screening and inclusion process.

Figure 6.1: PRIMSA flowchart



6.4.2 Study Characteristics:

Overall, 36 studies took place in Sub-Saharan Africa, and 12 studies were conducted among members of the African diaspora. Specifically, 12 were conducted among African Americans residing in the USA, 12 were conducted in South Africa, 8 in Nigeria, 3 in Zimbabwe, and 3 in Kenya. Other study countries included Uganda (n=2), Rwanda (n=2), Zambia, Angola, Mozambique, Malawi, Madagascar,

and Senegal (n=1 each). Interventions in the included studies targeted a variety of populations, with the ages of study participants ranging from 10 to 70 years. Unfortunately, only 6 studies reported the baseline HIV status of their study population, with 4 reporting both HIV+ and HIV- participants, and 2 being conducted only in HIV+ individuals (42 studies did not provide data on baseline HIV status). Most studies were randomized controlled trials (RCTs) (n=18), 13 were one-arm repeated measures studies (pre-post), 8 were quasi-RCTs, 4 were cluster or group RCTs, 3 were non-randomized controlled trials, one was described as a quasi-experimental study, and one as a matched control study. Study sample sizes ranged from 36 to 11,448 participants. The oldest study was published in 1990, and the most recent in 2017. **Appendix 6.2** provides further details on study characteristics.

The most common specific types of interventions administered were peer education interventions (n=8), computer-based interventions (n=3), behaviour change interventions (n=2), scenario-based or role-play interventions (n=2), and integrated psychosocial or psychological interventions along with HIV education (n=2). Other intervention types included audio-based interventions (n=1), mass media campaigns (n=1), and radio-based interventions. In addition, several studies included multiple intervention components or approaches. For example, peer education and videos were used in combination with other intervention components or mediums among the included studies (n=4, and n=2, respectively). The different components of the interventions implemented in each included study are summarized in **Appendix 6.3**. Educational interventions that did not involve a particular medium or defining element or specific approach other than the communication of HIV/AIDS information (e.g. through lectures) were classified as educational / informational interventions (n=7). Most (n=32) interventions were implemented at the group-level, whilst 9 were targeted at individuals, 3 had both individual and group components, 1 was aimed at couples, and 3 were mass campaigns or community-level interventions. The length of group or individual intervention programs varied between one-hour one-time interventions to interventions that lasted up to 2 years with multiple sessions over this time, whilst mass campaigns tended to be longer (lasting up to 4 years).

6.4.3 Intervention Effects on HIV-Related Knowledge

Knowledge of Risk Reduction through Condom Use: This outcome assessed whether respondents knew that using condoms during sex reduces one's risk of HIV infection. Results for this outcome are shown in **Table 6.2**. 12 studies reported data on knowledge of condom use as a measure of HIV risk reduction, with 6 reporting significant increases in respondents with correct knowledge in the intervention group. These 6 studies assessed peer or community education interventions (n=3), (97-99)

general educational/informational intervention programs (n=2),(100, 101) and video-based interventions (n=1).(102) Interestingly however, one of the 12 studies reported a lower proportion of respondents with correct knowledge in the intervention group at follow-up compared to in the control group at follow up (57.5% vs. 90.2%, respectively), and this difference was statistically significant ($p<0.005$).(103) This study administered a faith-based intervention, which was delivered by peers (adolescents) in the intervention group and by non-peers (older adults) in the control group, thereby being contrary to other studies in this review, which report generally successful outcomes in peer-led interventions, as mentioned below.(97, 98, 104)

Transmission Knowledge: Overall, 11 studies assessed knowledge of sexual transmission, 5 assessed knowledge of transmission via blood, and 7 assessed knowledge of transmission through contact with infected sharps (e.g. needles). **Table 6.3** summarizes the results of intervention effects on knowledge of transmission modes of HIV. For knowledge of transmission through sexual contact, all studies that showed significant improvement in the intervention group were studies whose intervention contained peer education elements.(97, 98, 104) Notably, for knowledge of transmission through contact with infected blood, all 5 studies that reported on this outcome reported improvement in the intervention group, but this was only stated as significant in one study, whilst the remaining studies did not report p-values.(98)

6.4.4 Intervention Effects on Condom Use

Condom use was defined in several ways (e.g. number of unprotected sex acts) and over various time points, depending on the study. Results regarding mean condom use are shown in **Appendix 6.4**, and categorical data for condom use (e.g. proportion of respondents reporting consistent condom use) are shown in **Appendix 6.5.** Six studies reported a lower mean number of unprotected sex acts in the intervention group at follow up compared to the control group at follow-up, and one (which did not have a control group), reported a decrease in unprotected sex acts among participants at follow-up compared to at baseline. Overall, 4 of these studies reported statistically significant differences.(77, 90, 94, 105) One study, which conducted 2 follow-up assessments, reported a higher number of unprotected sex acts with commercial partners among the intervention group than among the control group at the first follow-up, but ultimately fewer unprotected sex acts with commercial partners in the intervention group than in the control group at the second follow-up,(106) and a further study reported a higher propotion of unprotected vaginal sex acts in the intervention group at follow-up compared to

the control group at follow-up, but did show a decrease in unprotected sex acts from baseline to follow-up in the intervention group (although significance was not reported).(95)

6.4.5 Intervention Effects on HIV Incidence

Data pertaining to cases of HIV infection were reported in only 4 of the included studies, although one provided only baseline HIV prevalence data. Interventions assessed in these studies were peer education, participatory learning, and integrated mental health or intimate partner violence interventions along with HIV education. Results regarding HIV prevalence and incidence are shown in **Table 6.4.** Of the 3 studies reporting incident cases at follow-up, 2 reported a lower proportion of new cases in the intervention group compared to the control group (out of the number tested)(107, 108) (one assessing an integrated intimate partner violence reduction intervention and the other a participatory learning intervention), however, one, assessing a peer education intervention, reported a higher percentage of incident cases at follow-up in the intervention group.(109) For the two studies reporting HIV infection rates per 100 person years,(107, 108) both reported lower rates in the intervention group compared to the control group, although significance levels were not reported.

6.4.6 Influence of Improvements in HIV-related Knowledge on Condom Use

Although it is difficult to determine the precise role of increased HIV-related knowledge on subsequent sexual risk behaviour, as not all studies included in this review reported on all relevant outcomes, several observations of interest can be made in this regard. First of all, considering the possible influence of knowledge of sexual contact as a route of HIV transmission on subsequent sexual practices, of the three studies(97, 98, 104) that reported significant effects of their interventions on increased knowledge of the sexual transmission of HIV in the intervention group **(Table 6.3**), two also reported data on condom use. One reported a higher proportion of respondents always using a condom in the intervention group at follow-up compared to the control group (although no p-value was provided)(104), and the third(97) reported a significant increase in “any condom use” in the intervention group at follow-up compared to at baseline ($p<0.001$) (**Appendix 6.5**). Both of these studies implemented peer education based interventions.

Furthermore, of the six studies reporting significant increases in knowledge of condom use as a method of HIV prevention among the intervention group,(97-102) two also provided data regarding actual condom use. One of these studies has already been mentioned above, reporting a significant increase in “any condom use” in the intervention group at follow-up compared to at baseline ($p<0.001$)(97)

(**Appendix 6.5**). The second study however reported a lower proportion of condom use in the intervention group compared to the control at follow-up (although this difference was non-significant) (**Appendix 6.5**).(101)

Table 6.2. Intervention Effects on Proportions of Respondents with Correct Knowledge of Risk Reduction through Condom Use

Study (Ref, Year)	Study Country	Int Type	Sample Size (N)					P Value Type [a]	Proportion with Correct Answer to Risk Reduction Question (N) (unless otherwise stated)					
			Total	int bsl	cont bsl	int fu	cont fu		int bsl	cont bsl	P value	int fu	cont fu	P value
Using condoms during sexual intercourse can reduce the risk of HIV transmission (True)														
(110) 2013	Nigeria	CE	60	60		60		NA	41		NR	42		NR
(99) 1994	South Africa	CE	567	231	336	206	276	I	74	101	0.617	92	75	0.001
(111) 2013	South Africa	Comp / game	253	195		195		P	156		0.5	157		
(100) 1995	Zimbabwe	Ed	285	141	144	141	144	I	112	82	NR	113	64	<0.001
(112) 2012	South Africa	Ed	130	130		130		NA	52		NR	72		NR
(101) 2006	Zimbabwe	Ed	869			251	618	I				123	229	<0.001
(113) 2006	Nigeria	MM	6000	6000		NR		NA	86.2%	93.2%	NR	89.1%	95%	NR
(98) 2014	Nigeria	PE	400	200	200	195	192	P	139	146	0.0001	169	145	0.66
(97) 2007	Nigeria	PE / drama	1029	591	438	588	430	P	290	244	<0.001	443	250	NR
(103) 2008	USA	PE / Faith	101	40	61	40	61	I	27	51	NR	23	55	<0.005
(102) 2016	Mozambique	Video	915	NR	NR	462	453	I	NR	NR	NR	425	362	<0.001
(114) 1999	Nigeria	Video / scenario	450	233	217	223	210	NR	NR	NR	NR	215	132	NR

Bsl = baseline
CE = Community Education
Comp = Computer-based
Cont = Control
Ed = Educational / informational
Faith = Faith-based
Fu = Follow-up MM = Mass Media
Int = Intervention
NR = Not reported
PE = Peer education
Psych = integrated psychological counselling
Scenario = scenario-based/ role-play based

[a] P value type I= Int. vs. control, P = Pre- vs. Post-test. Where two p values are available, Int. vs. cont p values: 1st p value =Int, 2nd=Control. Pre-Post p values: 1st p value=pre-test, 2nd = post-test.

Table 6.3. Intervention Effects on Proportions of Respondents with Correct Knowledge of Modes of Transmission of HIV

Study (Ref, Year)	Study Country	Int Type	Sample Size (N)					P Value Type [a]	Proportion with Correct Answer to Transmission Route Question (N) (unless otherwise stated)					
			Total	int bsl	cont bsl	int fu	cont fu		int bsl	cont bsl	P value	int fu	cont fu	P value
HIV can be transmitted through sexual contact (True)														
(110) 2013	Nigeria	CE	60	60		60		NA	50		NR	55		NR
(115) 2016	Madagascar	Ed	155	28		28		P	0.64 (0.49) [b]		NR	0.64 (0.49) [b]		
(116) 2011	South Africa	Ed	103	58	45	58	45	NA	32	30	NR	38	23	NR
(100) 1995	Zimbabwe	Ed	285	141	144	141	144	I	125	123	NR	127	104	ns
(113) 2006	Nigeria	MM	6000	6000		NR		NA	79.5%		NR	86.3%		
(104) 2013	Nigeria	PE	160	80	80	80	80	I	70	34	<0.001	60	34	<0.001
(98) 2014	Nigeria	PE	400	200	200	195	192	P	184	182	<0.001	194	178	0.82
(117) 2012	Kenya	PE	442			145	297	NA			NR	124	200	NR
(118) 2000	Senegal	PE	260	247		247		NA	235		NR	240		NR
(97) 2007	Nigeria	PE / drama	1029	591	438	588	430	P	426	307	<0.001	582	322	NR
(114) 1999	Nigeria	Video / scenario	450	233	217	223	210	NA	192	183	NR	220	178	NR
HIV can be transmitted through contact with infected blood (True)														
(110) 2013	Nigeria	CE	60	60		60		NA	48		NR	55.98		NR
(116) 2011	South Africa	Ed	103	58	45	58	45	NA	49	33	NR	58	45	NR
(113) 2006	Nigeria	MM	6000	6000		NR		NA	24.90%		NR	29.80%		
(98) 2014	Nigeria	PE	400	200	200	195	192	P	186	176	0.02	192	173	0.71
(114) 1999	Nigeria	Video / scenario	450	233	217	223	210	NA	NR	NR	NR	210.066	166	NR
HIV can be transmitted through contact with contaminated sharps (e.g. needles) (True)														
(119) 2010	Nigeria	Aud	1205	595	560	513	461	I	524	439	<0.0001	483	373	0.0003
(110) 2013	Nigeria	CE	60	60		60		NA	49		NR	56		NR
(116) 2011	South Africa	Ed	103	58	45	58	45	NA	49	35	NR	58	44	NR
(112) 2012	South Africa	Ed	130	130		130		NA	101		NR	104		NR
(113) 2006	Nigeria	MM	6000	6000		NR		NA	39.10%		NR	46.50%		
(98) 2014	Nigeria	PE	400	200	200	195	192	P	180	178	0.03	188	159	0.24
(114) 1999	Nigeria	Video / scenario	450	233	217	223	210	NA	NR	NR	NR	197	129	NR

Aud = Audio-based
Bsl = baseline
CE = Community Education
Comp = Computer-based
Cont = Control
Ed = Educational / informational
Fu = Follow-up
Int = Intervention
MM = Mass Media
NR = Not reported
PE = Peer education
Scenario = scenario-based /role-play based

[a] P value type I= Int. vs. control, P = Pre- vs. Post-test. Where two p values are available, Int. vs. cont p values: 1st p value =Int, 2nd=Control. Pre-Post p values: 1st p value=pre-test, 2nd = post-test.

[b] Mean (SD)

Table 6.4. Intervention Effects on HIV Infection Outcomes

Study (Ref, Year)	Study Country	Int type	Sample Size (N)					P value type [b]	HIV Prevalence and Incidence (N Cases)							
			Total N	N int [a]	N cont	N int fu	N cont fu		int bsl (Prevalence)	int fu (Incidence)	p value	cont bsl (Prevalence)	Cont fu (Incidence)	P value	Rate per 100 py int	Rate per 100 py cont
(109) 2007	Zimbabwe	PE	9,454	4,792	4,662	6,015	5,993	I	1,172	123	<0.001	999	89	NR	NR	NR
(108) 2008	South Africa	PL	2776	1409	1367	1063 fu2: 1005	1006 fu2: 994	I	82	72	NR	104	81	0.56	3.46	4.07
(120) 2013	Rwanda	IMH	120	120	NA	120	NA	P	1/49	NR	NR	NA	NA	NA	NR	NA
(107) 2015 (women)	Uganda	IPV	6702	3158	3544	3775 (men and women)	4067 (men and women)	I	343/ 2814	56/ 1925	0·0026	448/ 3175	71/2038	0.396	0.99	1.15
(107) 2015 (men)	Uganda	IPV	4746	2179	2567			I	184/ 2789	27/ 1326	0·0288	253/ 2896	48/1435	0.045	0.70	1.13

Cont = Control Bsl = baseline Fu = Follow-up Int = Intervention
NR = Not reported PL = Participatory Learning PE = Peer education
IPV = integrated intimate partner violence intervention IMH = integrated mental health intervention

[a] When reported separately, total participants are shown under "sample size" and number tested is provided as the denominator for the outcome.
[b] P value type I= Int. vs. control, P = Pre- vs. Post-test. Where two p values are available, Int. vs. cont p values: 1st p value =Int, 2nd=Control. Pre-Post p values: 1st p value=pre-test, 2nd = post-test.

6.4.7 Meta-analyses

Knowledge of risk reduction through condom use: 8 of the included studies provided post-intervention data on knowledge of risk reduction through condom use in the intervention and control groups (respondents knowing that condom use is a method of HIV risk reduction) (See **Figure 6.2**). It was found that the intervention group had higher odds of knowing that the risk of HIV can be reduced through the use of condoms during sex than the control group in 7 of these studies (ORs ranging from 1.63 (95%CI: 1.21-2.20) to 15.88 (95%CI: 7.43-33.93), whilst in one study, (103) the intervention group had lower odds of correct knowledge than the control group (OR: 0.15, 95%CI: 0.05-0.42). It is relevant to note however, that in this study, the intervention group consisted of peers (adolescents) providing the knowledge intervention, and the control group consisted of adults providing the same intervention, suggesting that the intervention providers may have been a factor in its effectiveness, rather than solely the intervention itself.

The pooled OR for knowledge of condom use as a risk reduction measure across all 8 studies was 2.27, and the difference in odds of knowledge was insignificant (95%CI: 0.99-5.21, p=0.052), however, when separating this by intervention type, standard HIV education interventions were found to significantly increase the odds of correct knowledge among the intervention group (OR: 2.53, 95%CI: 1.33-4.82, p=0.005), whilst peer-led interventions were not (OR: 0.94, 95%CI: 0.17-5.07, p=0.941). Heterogeneity was high across the 8 studies (I^2 = 96.64), although slightly lower when only the three standard informational HIV knowledge interventions were considered (I^2 = 87.59).

Knowledge of transmission routes: As shown in **Figure 6.3,** 7 studies provided sufficient data for inclusion in the meta-analysis of intervention effect on knowledge of HIV transmission through sex. All of these studies reported higher odds of knowledge of sexual transmission in the intervention group compared to the control group, with the intervention group being from almost twice as likely to more than 32 times as likely as the control group to know that HIV can be transmitted through sex (ORs ranging from 1.82 (95%CI: 0.82-4.03) to 32.53 (95%CI: 14.14-74.86). The pooled OR for this outcome was 5.86 (95%CI: 2.65-12.97), and these higher odds of correct knowledge among the intervention group compared to the control were significant (p<0.001). When non-peer (n=3) and peer-led interventions (n=4) were pooled separately, both effect estimates remained significant, with higher odds of correct knowledge in the intervention group than in the control (non-peer education

interventions: OR: 4.02, 95%CI: 1.41-11.45, p=0.009; peer education interventions: OR: 7.94, 95%CI: 2.40-26.29, p<0.001).

Regarding knowledge of transmission through sharing of infected sharps, as is common practice when the effect measure is ORs, the one study reporting a zero-event (116) was not included in the model.(121) Although the inclusion of zero-event studies has shown to provide a more conservative effect estimate in meta-analyses,(121) the pooled effect estimate in this case was the same when the study was included as when it was dropped from the analysis (OR=4.35, 95%CI=3.21-5.89 vs. OR=4.35, 95%CI=3.21-5.90, respectively). The observed higher odds of correct knowledge in the intervention group for this outcome were significant (p<0.001).

Figure 6.2. Meta-analysis: Pooled Effect of HIV Knowledge Interventions on Knowledge of HIV Risk Reduction Through Condom Use (Odds Ratios of Correct Knowledge of Risk Reduction Through Condom Use in the Control vs. Intervention Group at Follow-up)

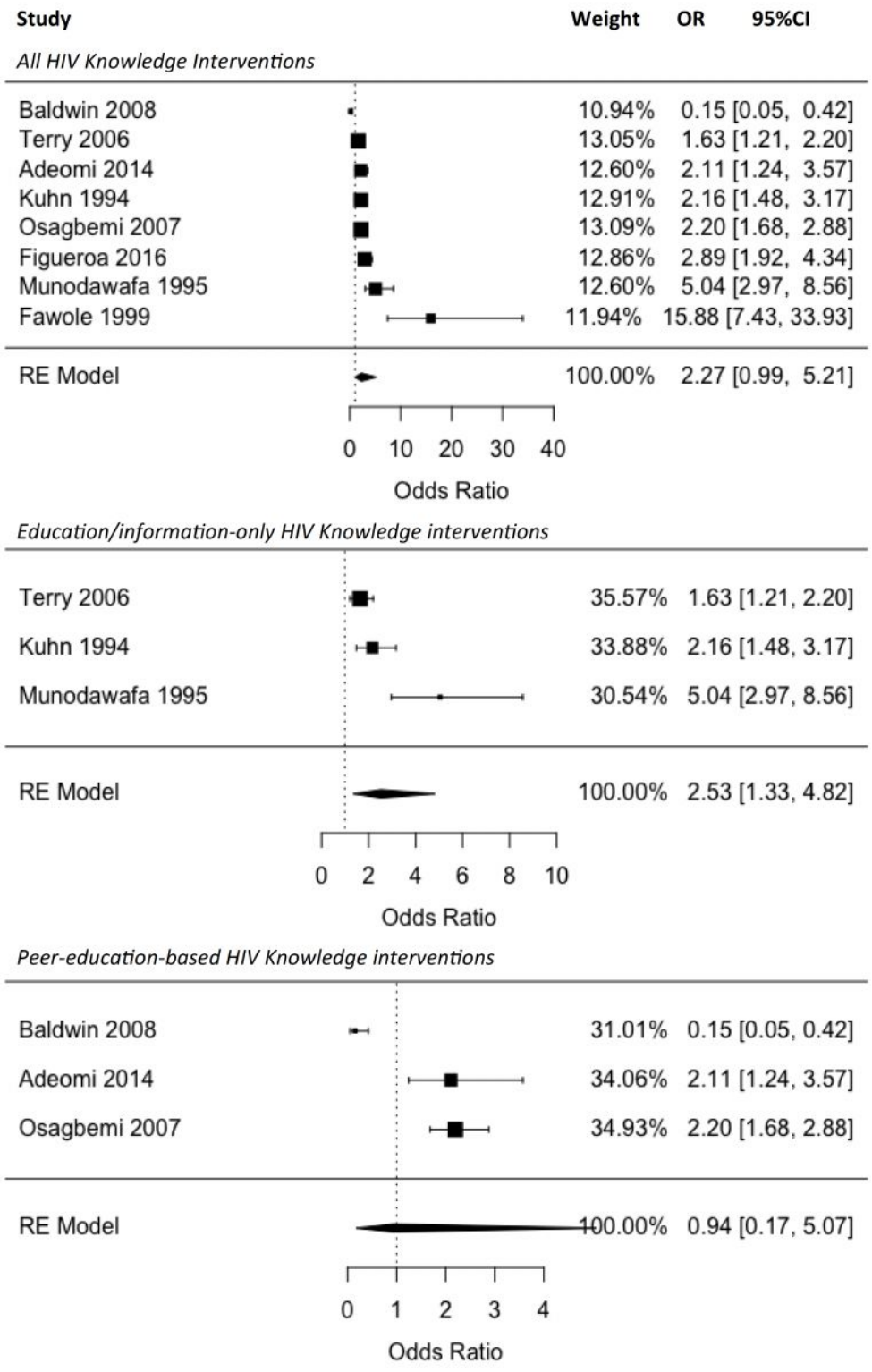
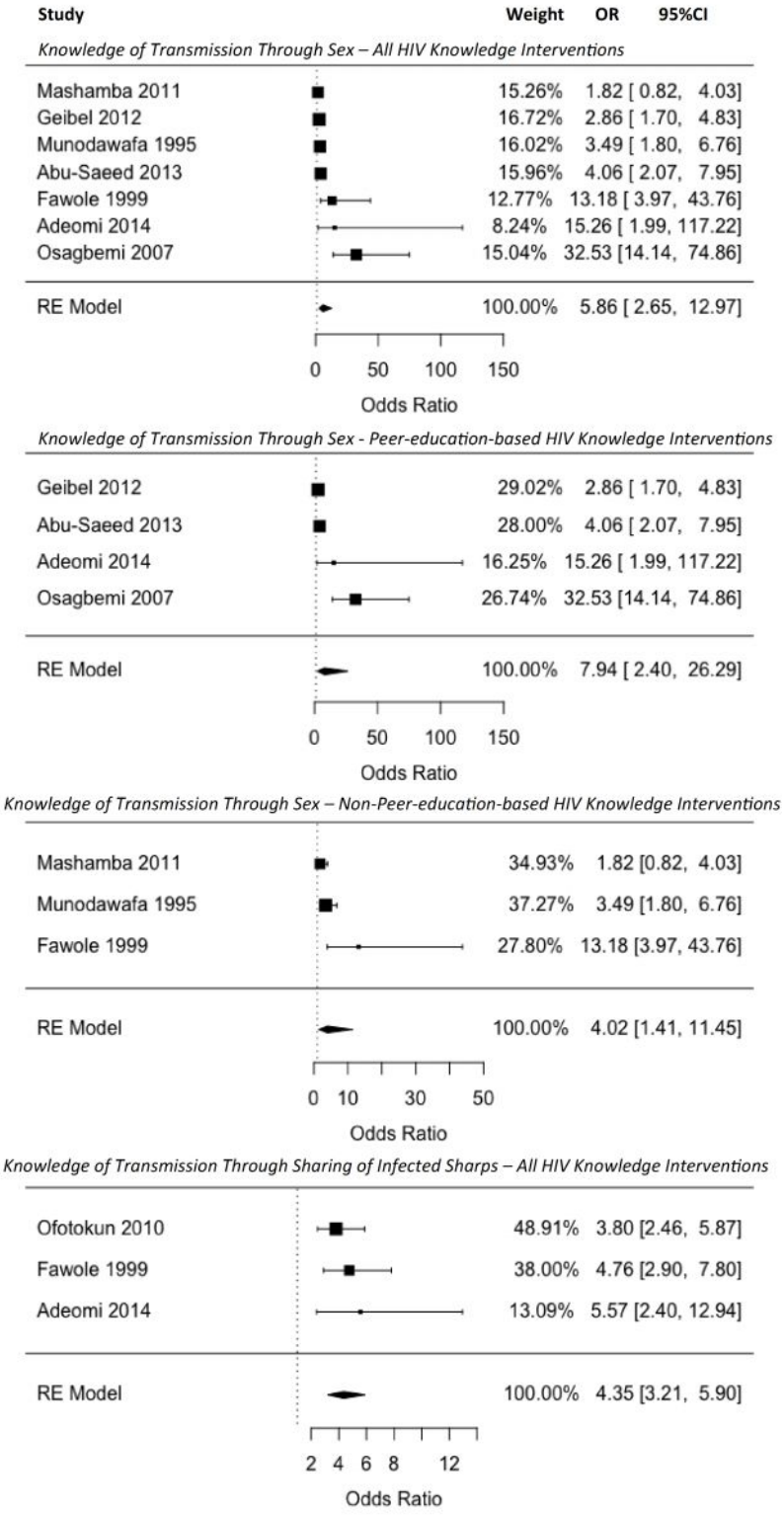
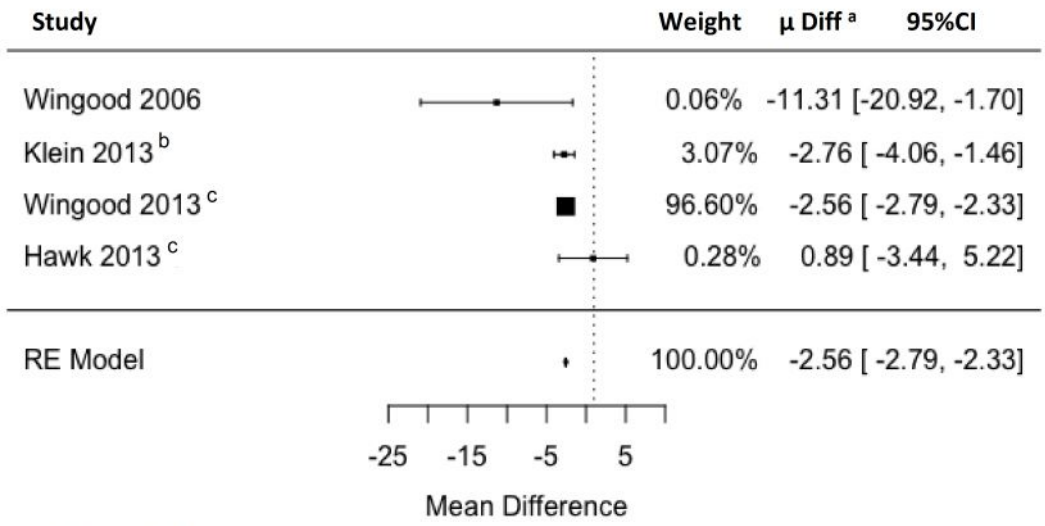


Figure 6.3. Meta-analysis: Pooled Effect of HIV Knowledge Interventions on Knowledge of HIV Transmission Routes (Odds Ratios of Correct Knowledge in the Control vs. Intervention Group at Follow-up)



Condom Use: Categorical data for condom use was not meta-analysed due to the heterogeneity in definitions of condom use, use during specific types of sexual activity or with specific types of partners, and time intervals of use, as well as due to the lack of uncertainty in the comparability across studies of measures such as "consistent condom use". A meta-analysis of continuous data on condom use, measured as mean number of unprotected sex acts over the measured time interval, is shown in **Figure 6.4**. The unstandardized mean difference (μ difference) was used as the effect measure as the individual studies did not use differing scales for this outcome (mean condom use was measured in each study). As shown in **Figure 6.4**, the mean number of unprotected sex acts was lower in the intervention than in the control group, with a pooled mean difference of 2.56 fewer sex acts among the intervention group than the control group (μ difference: -2.56, 95%CI: -2.79 – -2.33). Notably, this difference in mean sex acts in the intervention vs. control group was significant ($p<0.001$), although it should be noted that one study contributed very highly to the overall random-effects model in comparison to the other studies.

Figure 6.4. Meta-analysis: Pooled Effect of HIV Knowledge Interventions on Condom Use (Difference in Mean Number of Unprotected Sex Acts in Control vs. Intervention Groups at Follow-up)

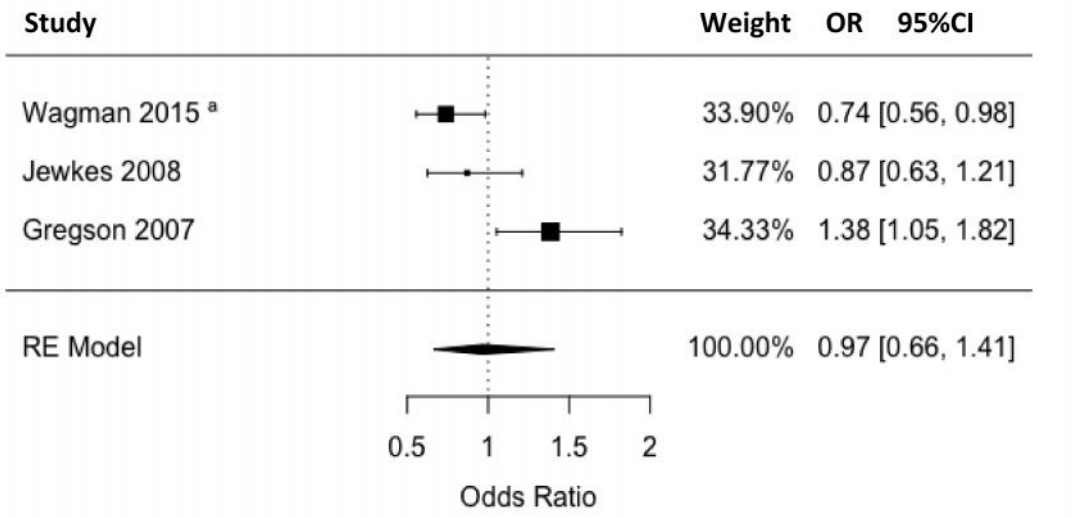


[a] Unstandardized difference in means
[b] Vaginal and anal sex acts
[c] Vaginal sex acts

HIV incidence: **Figure 6.5** displays a meta-analysis of the 3 studies that provided post-intervention data for HIV incidence. Two studies reported lower odds of HIV infection in the intervention group compared to the control, whilst one reported higher odds in the

intervention group. The pooled OR was 0.97 (95%CI: 0.66-1.41), indicating slightly lower odds of HIV infection among individuals receiving an HIV education intervention compared to those not receiving one, however, this difference was not significant (p=0.854), and it should be noted that the confidence interval crosses OR=1, indicating uncertainty regarding the true effect direction.

Figure 6.5. Meta-analysis: Pooled Effect of HIV Knowledge Interventions on HIV Incidence (Odds Ratio of HIV infection in Control vs. Intervention Group at Follow-up)



[a] Female and male HIV incidence data were originally reported separately in this study, but are combined in the meta-analysis.

6.4.8 Quality Assessment of Included Studies

The methodological quality assessment of RCTs according to Cochrane Risk of Bias criteria (49) is summarized in **Figure 6.6.** Quality assessment outcomes for non-RCTs, based on the same criteria, are shown in **Figure 6.7**. The Cochrane Risk of Bias Tool includes criteria such as random sequence generation, measures taken to initially conceal group assignment, blinding of participants or data analysts, and measures to reduce contamination between study groups. Studies are then given a risk ranking of "low", "unclear" or "high" risk. See **Appendix 6.6** for separate risk levels in each criterion for each study.

In general, RCTs were found to be of acceptable methodological quality, although a useful assessment of all criteria was not possible due to lack of detailed reporting, leading to many criteria being ranked as "unclear" in most studies. This lack of reporting was particularly true for criteria such as random sequence generation and allocation concealment, as although studies stated that group assignment was random, most did not specify how assignment was

randomized (e.g. was a random number sequence generated?), and only one study specified that initial allocation was concealed (using opaque envelopes). (94) Moreover, most studies did not clearly mention whether participants or intervention facilitators were blinded, although given the nature of the interventions, it is reasonable to assume that blinding was not possible. A greater concern however was that it was also often not stated whether data analysts were blinded to group assignment, which would have technically been possible and should have been specifically reported. Furthermore, as most studies did not have prior registered study protocols, it was difficult to assess whether outcomes had been pre-specified and whether they had been fully reported as planned in the protocol, therefore limiting the assessment of selection bias, with only five studies being classified as "low risk" for this criterion. On the other hand, a criterion that was generally well addressed by studies was ensuring that baseline characteristics were similar between study groups, with 15 studies providing a baseline comparison and either reporting insignificant p values (<0.05), or adjusting for significant differences in their subsequent analyses.

Apart from the expected higher risk scores on randomization, non-RCTs showed similar shortcomings with respect to reporting, with most not providing enough information to assess methodological quality regarding selective outcome reporting, or measures to reduce contamination.

The quality of pre-post studies was assessed using the Quality Assessment Tool for Before-After Studies with No Control Group (51) with results shown in **Table 6.5**. This assessment tool ascribes a total risk score to each study based on 11 criteria, including the recruitment of a representative sample, the justification of sample size, and appropriate reporting of attrition bias. Total risk scores are then categorized into overall rankings of low (total score 76-100%), moderate (26-75%) or high risk (0-25%). All included pre-post studies scored within the moderate risk category, with scores ranging from 45.45% to 72.73% (5/11 to 8/11). Main factors contributing to lower study quality (see **Appendix 6.7**) were the absence of multiple before and after measures (no studies had multiple pre and post-intervention data collection points), and the inadequate reporting of attrition (loss-to-follow-up) or a lack of statistical comparison of those who completed the study to those who did not, although other criteria were well addressed across studies, such as the clear stating of study objectives and intervention activities.

Overall therefore, the concerns revealed in this risk assessment regarding the quality of the included studies are more concerns relating to the lack of sufficient detail in reporting of relevant methodological components rather than any explicitly identified methodological flaws.

Figure 6.6. Risk of Bias Assessment for Randomized Controlled Trials

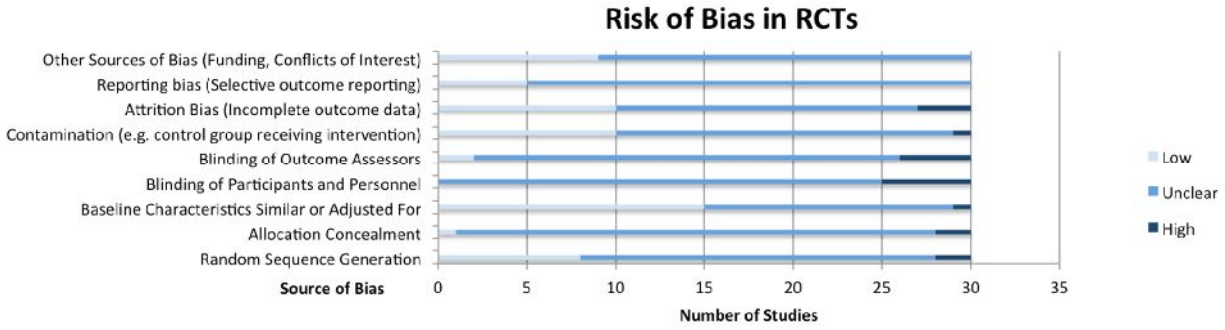


Figure 6.7. Risk of Bias Assessment for Non-randomized Controlled Trials

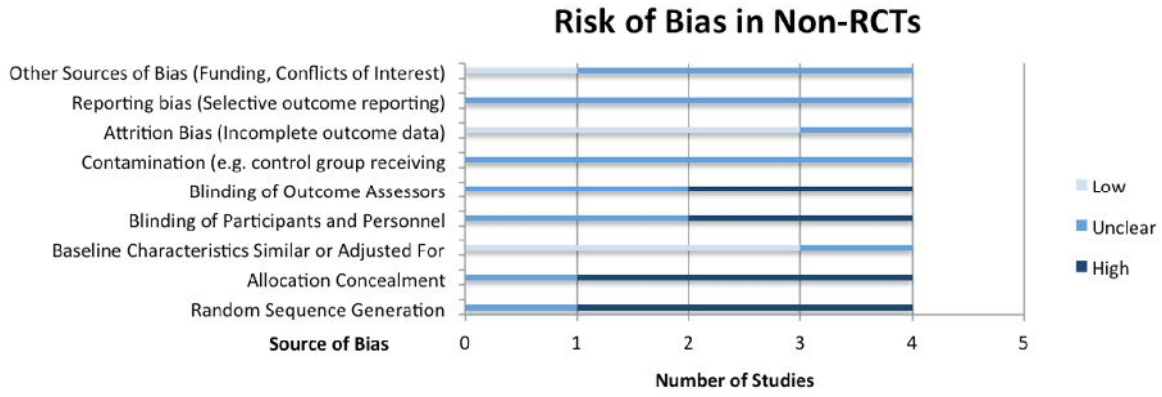


Table 6.5. Risk of Bias Assessment for Pre-Post or uncontrolled studies

Ref	First Author	Year	Total Risk Score [a] (out of 11 criteria [b])	% score	Final Risk Level (0-25% = high risk, 26-75% = moderate risk, 76-100% = low risk)
(110)	Ajuwon	2013	6	54.55	Moderate
(84)	Cornelius	2013	8	72.73	Moderate
(115)	Klinger	2016	8	72.73	Moderate
(118)	Leonard	2000	8	72.73	Moderate
(113)	Manafa	2006	6	54.55	Moderate
(122)	Miller	2008	7	63.64	Moderate
(112)	Ndebele	2012	7	63.64	Moderate
(105)	Sapiano	2013	8	72.73	Moderate
(111)	Srinivas	2013	5	45.45	Moderate
(120)	Talbot	2013	7	63.64	Moderate
(123)	Visser	2005	5	45.45	Moderate
(88)	Wilson	2014	8	72.73	Moderate
(124)	Temmerman	1990	6	54.55	Moderate
(117)	Geibel	2012	7	63.64	Moderate

[a] See **Appendix 6.7** for specific scores on each of the 11 criteria.
[b] One of the original tool's criteria; "in the case of group-level interventions, adjustments made for use of individual data to determine group level effects", was not relevant to any of the included studies, and, as recommended by the tool developers, was thus not included in the assessment.

6.5 Discussion

The included studies spanned countries across Sub-Saharan Africa, as well as members of the African diaspora, and assessed a wide variety of HIV-related knowledge intervention types, ranging from peer-education to video-based interventions.

Regarding improving knowledge of transmission routes, peer-based educational interventions seem to be particularly effective, with all three sudies that demonstrated significantly higher knowledge of sexual transmission of HIV among the intervention group having administered peer-education interventions. (97, 98, 104) Similarly, intervention types that were associated with significant improvements in knowledge of condom use as a measure of HIV risk reduction as well as increased actual condom use included peer-education, community-level education, video-based educational interventions, and standard HIV educational interventions (e.g. non-peer-led information sessions). (97-102) Meta-analyses for knowledge outcomes showed significantly higher odds of correct knowledge among the intervention group of both, transmission through sharps (OR=4.35, 95%CI=3.21-5.90, $p<0.001$), as well as through

sexual intercourse (OR: 5.86, 95%CI: 2.65-12.97, p<0.001). In addition, although participants in peer-led interventions had non-significant higher odds of knowledge of condom use as a means of HIV risk reduction, participants in standard HIV educational interventions were found to have significantly higher odds of correct knowledge of condoms as a risk reduction method, and, among studies reporting actual condom use, fewer unprotected sex acts were found to occur post-intervention in the intervention groups compared to the control groups.

With regards to HIV incidence, although the meta-analysis indicated only slightly lower pooled odds of HIV infection among the intervention groups (OR: 0.97, 95%CI: 0.66-1.41, p=0.854), it is interesting to note that among the two studies that reported lower HIV incidence in the intervention group, one administered an intervention integrating HIV education with intimate partner violence reduction. This suggests that addressing intimate partner violence along with HIV-related knowledge may be important for reducing sexual risk behaviour and subsequent transmission.

Although the included studies generally had low to moderate risk of bias scores, an accurate evaluation of study quality was hindered by inadequate reporting of relevant methodological elements, particularly with respect to randomization and group assignment procedures in the case of RCTs, and measures taken to reduce contamination across intervention groups.

Further limitations of this study include the reliability of the meta-analysis. Although studies were quite homogenous and precise in their measurement methods for the meta-analysed outcomes (such as mean number of unprotected sex acts), considerable heterogeneity was present regarding the interventions evaluated. Although all included studies assessed HIV-related knowledge interventions, the format and mode of delivery of these educational interventions varied (e.g. peer education, video-based, or drama-based educational interventions), leading to fairly high heterogeneity in the studies (as indicated by the fact that I^2 values were above 75% in most of the random-effects models). This therefore implies that the resulting pooled effect estimates should be interpreted with caution, and further studies reporting on the different intervention types and providing sufficient data for the outcomes of interest are required so that a sufficient number of studies will be available for separate meta-analyses for each precise format or delivery mode of HIV educational interventions. In addition, further studies are needed that evaluate HIV-related knowledge interventions and also provide actual HIV incidence data post-intervention, as only three studies did so in the

current review, limiting the conclusions that can be drawn regarding the relationship between improvements in HIV-related knowledge and ultimate HIV transmission risk.

6.6 Conclusion

In summary therefore, peer education appears to be effective in informing individuals about HIV transmission routes, whilst conventional informational interventions appear to be more effective for communication of risk reduction measures. Regarding actual HIV transmission, although further studies are required on the effect of improved HIV-related knowledge on ultimate transmission risk, the current review indicates that it may be of interest to incorporate not only HIV-related knowledge regarding transmission routes and risk reduction measures into HIV interventions, but rather also include components addressing underlying sources of HIV risk other than lack of knowledge, such as issues of female disempowerment and intimate partner violence.

6.7 Competing interests

The authors have no competing interests to declare.

6.8 Authors' contributions

LF and SY were responsible for study design. LF conducted the data collection and analysis and was responsible for drafting the manuscript. All authors read and approved the final draft.

6.9 Relevant Appendices

- Appendix 6.1 Systematic Review of HIV-Related Knowledge Interventions – Search Strategy
- Appendix 6.2. Summary of Characteristics of Included Studies
- Appendix 6.3. Types and Components of Interventions Implemented in the Included Studies
- Appendix 6.4. Intervention Effects on Mean Condom Use
- Appendix 6.5. Intervention Effects on Proportion of Participants Using Condoms
- Appendix 6.6. Risk scores across criteria for each RCT and N-RCT study (assessed via the Cochrane Risk of Bias Tool).

- Appendix 6.7. Component criteria of total risk scores for pre-post and other uncontrolled studies (assessed via the Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control).

CHAPTER SEVEN: INTEGRATED DISCUSSION AND CONCLUSION

7.1 Significance of Results

As established in Papers 1 and 2, the overall level of HIV-related knowledge in Nigeria is low, particularly among marginalized groups such as the poor, those living in rural areas, and those with low literacy levels. This suggests that sexual health and HIV-related educational interventions should be preferentially targeted at these marginalized population subgroups.

Considering wealth inequality rather than simply absolute wealth, despite the fact that prior studies in other Sub-Saharan African countries have indicated that high wealth inequality is associated with a higher risk of HIV transmission(2, 3, 25, 26), the current study reports similar odds of low overall HIV-related knowledge across wealth inequality categories. However, importantly, when exploring the interaction effect of wealth inequality with sex (in Paper 1), it was found that females have more than twice the odds of low overall HIV-related knowledge in comparison to males at all levels of wealth inequality, suggesting that women are more vulnerable to low HIV-related knowledge, and by extension less able to advocate for preventive measures, under circumstances of wealth inequality. This indicates the need, in future prevention efforts, to consider not only absolute wealth, but also the unique issues arising (with respect to access to knowledge and capacity to translate knowledge into preventive actions) as a result of unequal wealth distribution, particularly in the context of female disempowerment. Moreover, the finding, in Paper 2, that knowledge of HIV transmission in Nigeria was best approximated in the ARIMA model using the mean state-level wealth inequality ratio as the single predictor (i.e. the finding that the trend in knowledge of HIV transmission to some extent follows the trend in state-level wealth inequality) underlines that under circumstances of inequality, individuals experience greater barriers to accessing HIV-related health information. Ultimately, they may in turn also experience greater barriers to translating this information into the adoption of appropriate preventive behaviours.

Regarding the identification of further risk groups, the observed low HIV-related knowledge in the 15-24 year old age group compared to the 25-34 year old group (in Paper 1) suggests earlier HIV education and intervention among younger adults would be warranted, to ensure that HIV-related knowledge is improved before rather than after sexual debut. In addition, the trend analysis in Paper 2 indicated that disparities in HIV-related knowledge levels between

States have widened over time, suggesting that States with particularly low knowledge levels (Zamfara, Kebbi, and Bauchi) should be priority targets for future intervention efforts.

Considering specific knowledge domains, the results of Paper 2 regarding the significant decrease in knowledge of MTCT in 2013 compared to 2003 is particularly concerning, given the ongoing contribution of MTCT to the Nigerian HIV epidemic.(13) In combination with the finding in paper 1 that knowledge of MTCT is higher among females than males, it may be of interest to ensure that educational interventions focusing on MTCT are targeted also at males rather than primarily at women, especially in contexts where prevailing social norms designate men as the ultimate decision-makers regarding sexual practices and women's reproductive health or perinatal care-seeking.

Apart from the identification of subgroups with low HIV-related knowledge for targeted intervention, it is also relevant to identify the precise domains in which accurate knowledge is most lacking within these target populations. As mentioned above, females for example had higher knowledge of MTCT than males, but were found to have lower knowledge of risk reduction measures, indicating the need for increased emphasis on risk reduction methods in female-targeted HIV educational programming (and perhaps with a particular focus on female-driven preventive methods such as female condoms). On a similar note regarding intervention content, specific programming emphasizing the knowledge areas of risk reduction and prevention of MTCT is needed among adolescents and young adults (the 15-24 year old age group).

Furthermore, having covered considerations regarding both content and specific target groups for future intervention efforts, a further relevant consideration includes the mode of delivery. For example, having found significantly lower HIV-related knowledge levels among individuals with low literacy (Paper 1), and having observed that this disparity has persisted over time (Paper 2), efforts should urgently be made to adapt interventions to this group through the use of non-text-based media or verbal communication.

As Papers 1 and 2 investigated the trends in and socioeconomic correlates of HIV-related knowledge, but did not provide insight into whether improved HIV-related knowledge leads to a higher likelihood of adoption of preventive behaviour or a lower likelihood of ultimate HIV infection, Paper 3 makes a pertinent contribution to this work. Apart from investigating

whether HIV-related knowledge interventions had favourable effects on preventive behaviours and HIV incidence in previous studies, the paper also synthesises the evidence for the effectiveness of different types of educational interventions in improving HIV-related knowledge.

In general, it was found that peer-based educational interventions were particularly effective at generating significant improvements in knowledge of HIV transmission routes, whilst intervention types that were associated with significant improvements in knowledge of condom use as a measure of HIV risk reduction as well as increased actual condom use included peer-education, community-level education, video-based educational interventions, and standard HIV educational interventions (e.g. non-peer-led information sessions).

Regarding actual HIV transmission, unfortunately only three studies reported data on post-intervention HIV incidence, and the meta-analysis showed an insignificant pooled effect of the interventions on incidence, suggesting that further research to ascertain the association between HIV-related knowledge and HIV transmission is needed. However, the review indicates that incorporating components in future HIV educational interventions that also address underlying sources of HIV risk, such as issues of female disempowerment and intimate partner violence, (rather than solely prevention knowledge), may be effective in reducing HIV transmission.

7.2 Limitations

Significant limitations of Paper 1 include the predictive capacity of the logistic regression model, which calls for caution when interpreting the findings of the model regarding the identified high-risk groups for low HIV-related knowledge. Moreover, the lack of individual HIV incidence data in the NDHS precluded the analysis of the association of HIV-related knowledge with ultimate HIV infection risk, which was also a limitation of Paper 2, restricting the value of the findings of both studies in terms of their direct implications for the evidence-based targeting of HIV preventive interventions among high-risk groups.

An additional limitation of both papers was the missing data for literacy (n=185, n=423, and n=399 respondents with missing data in the 2003, 2008 and 2013 surveys, respectively). In the 2013 survey for example, although individuals with missing data for literacy did not differ significantly from those with available data on demographic characteristics such as age, sex

and employment status, they were however found to be significantly more likely to live in rural areas and in States with high wealth inequality, and were significantly less likely to belong to dominant ethnic groups. This observation is consistent with the method of literacy data collection in the NDHS, given that literacy cards were used to assess respondents' reading skills, however, these cards were not available in all Nigerian languages, making speakers of minority languages less likely to have completed literacy assessments. Given that, for example, individuals living in rural areas were found to be more likely to have low HIV-related knowledge, the fact that they were also less likely to have available literacy data and were thus excluded from the analysis presents a validity concern, and suggests that actual levels of HIV-related knowledge in Nigeria may be lower than reported here.

Further considering Paper 2, the small number of time points available between 2003 and 2013 limited the time series analysis, as it precluded the production of trend forecasts from the ARIMA models, and significantly restricted the interpretation of which factors have influenced the observed trend in HIV-related knowledge over time. Moreover, given that NDHS data is not longitudinal, it was not possible in the current analysis to investigate how individual-level changes in factors such as absolute wealth, wealth inequality, educational attainment and other socio-economic indicators influence changes in individual-level HIV-related knowledge over time.

With regard to Paper 3, notable limitations of the meta-analyses include the heterogeneity in the formats and modes of delivery of the interventions (e.g. peer-based vs. video-based interventions), although all interventions shared an HIV prevention education mandate. It would be methodologically favourable to estimate pooled effect sizes specific to each intervention format / delivery mode, however, this would require a considerable number of further studies evaluating each intervention type, and providing sufficient data on outcomes of interest. In addition, the lack of detailed reporting of study methodologies (e.g. randomization procedures) limited the accuracy of the risk of bias assessment of included studies, thus leading to uncertainty regarding the quality of evidence presented in the meta-analyses.

7.3 Areas for Further Research

Given that the lack of HIV incidence data in the NDHS limited the analyses presented in Papers 1 and 2, and few studies in the meta-analysis (Paper 3) reported data on HIV

incidence, the relevance of future studies in the Nigerian context could be greatly strengthened by the inclusion of HIV incidence data in their analyses, allowing an examination of the role of HIV-related knowledge in subsequent HIV-related health behaviours and actual HIV transmission risk. In addition, the examination of wealth inequality as a direct predictor of actual HIV transmission risk (rather than HIV-related knowledge) in Nigeria would also be relevant, considering that individuals living in circumstances of socioeconomic inequality may be likely to face additional obstacles other than knowledge barriers, such as inadequate access to services or preventive measures, placing them at higher risk of HIV transmission, regardless of their level of HIV-related knowledge.

Lastly, considering the limited number of studies in the HIV-related knowledge intervention meta-analyses (Paper 3) reporting not only knowledge outcomes but also subsequent preventive behaviour and HIV incidence, the further evaluation of HIV prevention education interventions and their effect on HIV transmission is warranted, particularly with respect to which formats or modes of delivery of such interventions are most effective among specific risk groups.

7.4 Conclusion

Conclusively, being the first studies to investigate socioeconomic and demographic correlates of knowledge of HIV prevention and transmission among the Nigerian population, Papers 1 and 2 identify relevant risk groups at which to target HIV education interventions, and pinpoint specific knowledge areas that require improvement among each risk group. In response to evidence gaps encountered in Papers 1 and 2 regarding the influence of HIV-related Knowledge on subsequent preventive behaviours and HIV infection risk, Paper 3 contributes a meta-analysis of evaluated HIV educational interventions and their effects on HIV-related knowledge, subsequent use of preventive measures, and HIV incidence, providing a synthesis of evidence regarding which forms of HIV prevention education interventions are most effective not only in facilitating understanding of HIV transmission and prevention, but also inciting subsequent protective behaviour and ultimately reducing HIV infection risk. Taken together, this work therefore:

1) Identifies **target risk groups** for HIV prevention and educational interventions
2) Provides insight regarding **intervention content**, through identifying the specific areas of HIV-related knowledge that should be given increased focus in future

prevention efforts among particular target groups (e.g. knowledge of risk reduction measures among females)

3) Analyses the evidence for the **effectiveness** of HIV education interventions in improving knowledge, increasing use of preventive measures, and reducing HIV incidence

This work thereby offers a comprehensive contribution to our understanding of which groups are most at risk of low HIV-related knowledge in Nigeria, in which knowledge areas exactly knowledge is most lacking among particular groups, and how HIV prevention and education interventions can most effectively be targeted at these groups in order to not only improve HIV-related knowledge, but also encourage use of preventive measures, and ultimately reduce HIV transmission.

APPENDICES

Appendix 4.1. Questions included in computation of HIV-related knowledge scores in Papers 1 and 2

Question	Coding	
	Yes	No
1. Has heard of AIDS	1	0
2. Knows a place to get HIV testing	1	0
3. Knows a source for condoms [a]	1	0
4. To reduce the risk of getting HIV: always use condoms during sex	1	0
5. To reduce the risk of getting HIV: have one sex partner only, who has no other partners	1	0
6. Can contract HIV from mosquito bite	0	1
7. Can contract HIV by sharing food with person who has AIDS	0	1
8. Can contract HIV by witchcraft or supernatural means	0	1
9. A healthy looking person can have HIV	1	0
10. HIV can be transmitted during pregnancy	1	0
11. HIV can be transmitted during delivery	1	0
12. HIV can be transmitted by breastfeeding	1	0

[a] Initially "does not know any source of condoms" in NDHS, re-defined as "knows a source of condoms" for ease of interpretation

NB: A further potentially relevant question, whether the respondent knows about the existence of "drugs to avoid HIV transmission to baby during pregnancy," was not included in the total score, due to the high number of missing cases for this question.

Appendix 4.2. Comparison of Demographic Characteristics of Respondents With and Without Available Data for Literacy Level (2013 NDHS)

		Literacy Data Missing			Literacy Data Available		
		N	Layer Column %	Mean	N	Layer Column %	Mean
Sex	**Male**	106_a	26.6%		17253_a	30.9%	
	Female	293_a	73.4%		38655_a	69.1%	
Age				30_a			29_a
State-level Wealth Inequality Ratio Category	**<1.5**	42_a	10.5%		8423_b	15.1%	
	1.50 ≤ 1.79	135_a	33.8%		23274_b	41.6%	
	1.80 ≤ 2.19	214_a	53.6%		23061_b	41.2%	
	≥ 2.2	8_a	2.0%		1150_a	2.1%	
National Wealth Quintile	**Lower 20th**	110_a	27.6%		9138_b	16.3%	
	20-40th	82_a	20.6%		10466_a	18.7%	
	40-60th	88_a	22.1%		11451_a	20.5%	
	60-80th	77_a	19.3%		12415_a	22.2%	
	Upper 20th	42_a	10.5%		12438_b	22.2%	
Urban/Rural Residence	**urban**	117_a	29.3%		22572_b	40.4%	
	rural	282_a	70.7%		33336_b	59.6%	
Ethnicity	**Other**	155_a	38.8%		19950_a	35.7%	
	Fulani	74_a	18.5%		3305_b	5.9%	
	Hausa	84_a	21.1%		13402_a	24.0%	
	Ibibio	13_a	3.3%		1271_a	2.3%	
	Igbo	44_a	11.0%		7632_a	13.7%	
	Ijaw	8_a	2.0%		2347_b	4.2%	
	Yoruba	21_a	5.3%		8001_b	14.3%	
Currently Employed	**No**	144_a	36.1%		18716_a	33.5%	
	Yes	253_a	63.4%		36898_a	66.0%	
	Unknown	2_a	0.5%		294_a	0.5%	
Relationship Status	**Never in union**	93_a	23.3%		18258_b	32.7%	
	Currently in union or co-habiting	292_a	73.2%		35539_b	63.6%	
	Formerly in union or co-habiting	14_a	3.5%		2111_a	3.8%	

Values in the same row and subtable not sharing the same subscript are significantly different at $p< 0.05$ in the two-sided test of equality for column proportions. Chi squared and column proportions tests used for the categorical * categorical comparisons. T test used for the continuous age variable.

Appendix 5.1. Comparison of Demographic Characteristics of Respondents With and Without Available Data for Literacy Level (2003 and 2008 NDHS)

		Survey Year: 2003						Survey Year: 2008 [1]					
		Literacy Data Missing			Literacy Data Available			Literacy Data Missing			Literacy Data Available		
		N	Layer Column %	Mean	N	Layer Column %	Mean	N	Layer Column %	Mean	N	Layer Column %	Mean
Sex	**Male**	101_a	54.5%		1992_b	20.9%		138_a	32.6%		13670_a	29.2%	
	Female	84_a	45.5%		7536_b	79.1%		285_a	67.4%		33100_a	70.8%	
Age				31_a			28_b			30_a			29_b
State-level Wealth Inequality Ratio Category	**<1.50**	0^2	0.0%		449_a	4.7%		37_a	8.7%		3610_a	7.7%	
	1.50-1.99	24_a	13.1%		897_a	9.4%		23_a	5.4%		3747_b	8.0%	
	2.00-2.49	0_a	0.2%		754_b	7.9%		84_a	19.8%		9716_a	20.8%	
	2.50-3.00	71_a	38.4%		1950_b	20.5%		146_a	34.5%		10661_b	22.8%	
	3.01-4.00	59_a	32.1%		3037_a	31.9%		74_a	17.5%		9616_a	20.6%	
	4.01-5.00	27_a	14.4%		1392_a	14.6%		57_a	13.5%		7391_a	15.8%	
	>5.00	4_a	1.9%		1048_b	11.0%		2_a	0.5%		2029_b	4.3%	
National Wealth Quintile	**Lower 20th**	29_a	15.4%		1748_a	18.3%		54_a	12.8%		8415_b	18.0%	
	40th	49_a	26.7%		1749_b	18.4%		79_a	18.7%		8487_a	18.1%	
	60th	41_a	21.9%		1865_a	19.6%		114_a	27.0%		8796_b	18.8%	
	80th	47_a	25.6%		1930_a	20.3%		95_a	22.5%		10006_a	21.4%	
	Upper 20th	19_a	10.4%		2236_b	23.5%		80_a	19.0%		11066_b	23.7%	
Rural / Urban Residence	**Urban**	49_a	26.4%		3372_b	35.4%		153_a	36.1%		16997_a	36.3%	
	Rural	136_a	73.6%		6155_b	64.6%		271_a	63.9%		29773_a	63.7%	

Ethnicity	**Other or unknown**	47_a	25.5%		3584_b	37.6%		119_a	28.7%		14888_a	31.9%
	Fulani	22_a	11.8%		554_b	5.8%		18_a	4.2%		2746_a	5.9%
	Hausa	90_a	48.3%		2494_b	26.2%		121_a	29.1%		10416_b	22.3%
	Ibibio	20_a	10.9%		333_b	3.5%		12_a	3.0%		1146_a	2.5%
	Igbo	3_a	1.4%		1321_b	13.9%		46_a	10.9%		7248_b	15.5%
	Ijaw	0^2	0.0%		118_a	1.2%		7_a	1.7%		1782_b	3.8%
	Yoruba	4_a	2.1%		1123_b	11.8%		93_a	22.3%		8386_b	18.0%
Employment Status	**Unemployed**	38_a	20.5%		3974_b	41.8%		96_a	22.8%		16036_b	34.5%
	Employed	146_a	79.5%		5535_b	58.2%		327_a	77.2%		30466_b	65.5%
Relationship Status	**Never married**	43_a	23.1%		2931_b	30.8%		96_a	22.7%		14849_b	31.8%
	Currently married	133_a	71.6%		6209_a	65.2%		312_a	73.7%		30284_b	64.8%
	Formerly married	10_a	5.3%		388_a	4.1%		15_a	3.6%		1632_a	3.5%

Values in the same row and subtable not sharing the same subscript are significantly different at $p< 0.05$ in the two-sided test of equality for column proportions. Chi squared and column proportions tests used for the categorical * categorical comparisons. T test used for the continuous age variable.

[1] See **Appendix 4.2** for 2013 survey data

[2] This category is not used in comparisons because its column proportion is equal to zero.

Appendix 6.1. Systematic Review of HIV-related Knowledge Interventions - Search Strategy

Database: Embase Date of Search: Nov 17th 2017

Search Step	Search Terms	Records Retrieved
1	knowledge/	30872
2	Awareness/	54186
3	program development/ or education program/ or program evaluation/	74638
4	intervention study/	35001
5	((Knowledge or awareness or understanding) adj5 (program* or course* or workshop* or intervention*)).ti,ab,kw.	30779
6	1 or 2	82883
7	3 or 4	108901
8	6 and 7	3041
9	5 or 8	33279
10	Human immunodeficiency virus/	101208
11	acquired immune deficiency syndrome/	131585
12	(human immunodeficiency virus or hiv or acquired immunodeficiency syndrome or AIDS).ti,ab,kw.	457419
13	10 or 11 or 12	493085
14	9 and 13	1787
15	"Africa south of the Sahara"/	11886
16	african/ or african american/	80373
17	(africa* adj4 (immigrant* or migrant* or origin* or ancestr* or american*)).ti,ab,kw.	78814
18 [a]	(Sub?Sahara* Africa* or Angola or Benin or Botswana or Burkina Faso or Burundi or Cameroon or Cape Verde or Central African Republic or Chad or Comoros or Congo or Cote d?Ivoire or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Mauritius or Mozambique or Namibia or Niger or Nigeria or Rwanda or Sao Tome or Senegal or Seychelles or Sierra Leone or Somalia or South Africa or South Sudan or Swaziland or Tanzania or Togo or Uganda or Zambia or Zimbabwe).ti,ab,kw.	348116
19	15 or 16 or 17 or 18	458761
20	14 and 19	452

Database: Medline Date of Search: Nov 17th 2017

Search Step	Search Terms	Records Retrieved
1	Awareness/	18984
2	knowledge/	10409
3	Health Knowledge, Attitudes, Practice/	100226
4	1 or 2 or 3	126758
5	Program Development/	28001
6	Program Evaluation/	59258
7	5 or 6	78777
8	((Knowledge or awareness or understanding) adj5 (program* or course* or workshop* or intervention*)).ti,ab,kw.	24313
9	4 and 7	6234
10	8 or 9	29545

11	hiv infections/ or acquired immunodeficiency syndrome/ or hiv seropositivity/	259901
12	(human immunodeficiency virus or hiv or acquired immunodeficiency syndrome or AIDS).ti,ab,kw.	390398
13	11 or 12	421482
14	10 and 13	2099
15	exp "africa south of the sahara"/	193104
16 [a]	(Sub?Sahara* Africa* or Angola or Benin or Botswana or Burkina Faso or Burundi or Cameroon or Cape Verde or Central African Republic or Chad or Comoros or Congo or Cote d?Ivoire or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Mauritius or Mozambique or Namibia or Niger or Nigeria or Rwanda or Sao Tome or Senegal or Seychelles or Sierra Leone or Somalia or South Africa or South Sudan or Swaziland or Tanzania or Togo or Uganda or Zambia or Zimbabwe).ti,ab,kw.	290867
17	exp African Continental Ancestry Group/	84666
18	(africa* adj4 (immigrant* or migrant* or origin* or ancestr* or american*)).ti,ab,kw.	58033
19	15 or 16 or 17 or 18	464591
20	14 and 19	644

[a] This is based on a current list of Sub-Saharan African countries, as classified by the United Nations Development Programme (125)

Appendix 6.2: Summary of Characteristics of Included Studies

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(104)	Abu-Saeed	2013	Nigeria	RCT	Adolescents &Young Adults	School	160	15-24	Peer education	G	Peer education intervention on various topics related to HIV/AIDS	4d	PE	NR	8w	
(98)	Adeomi	2014	Nigeria	RCT	Adolescents &Young Adults	School	400	10-19	Peer education	G	Peer education intervention, with peer educators trained through lectures, motivational talks, and demonstrations using audiovisuals, posters, role plays, and practical demonstrations to address the reproductive health questions of students	2w	PE	NR	12w	
(110)	Ajuwon	2013	Nigeria	Pre-Post	Adults	Comm	60	20-69	Community education	G	An educational intervention covering knowledge about HIV/AIDS, routes of transmission, prevention strategies, and attitude toward persons living with HIV, using posters, pamphlets, and drama presentations	1h, one-time	LIB	No cont. (a)	NR	
(103)	Baldwin	2008	USA	N-rct	Adolescents &Young Adults	Church	101	13-19	Faith-based Peer and non-peer education	G	Peer and adult-led faith-based educational intervention	2.5h, one-time	PE	Adult (non peer) FAC	Imm	
(126)	Billings	2015	USA	RCT	Women	Comm	83	18-50	Behavioural	I	Web-based behavioural intervention	1m	NA	DI	1m	4m
(106)	Bing	2008	Angola	RCT	Military personnel	Military bases	568	18-51	Motivational, behavioural	G	Military-focused education, motivation and behavioural HIV prevention intervention using illustrations(with monthly booster sessions)	4.5d	FAC	Malaria and shortened HIV intervention	3m	6m

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(85)	Card	2011	USA	Q-rct	Women	Planned parenthood clinic	135	18-29	Computer-based	I	Computer based intervention using flash modules and videos	2h, one-time	HE	GH	3m	
(84)	Cornelius	2013	USA	Pre-Post	Adolescents &Young Adults	Comm	40	13-18	Text messaging based	I	A mobile phone delivered HV prevention intervention	7w face-to-face, 3m texts	FAC	No cont.	7w	3m
(114)	Fawole	1999	Nigeria	Q-rct	School children	School	450	NR	Video / role play	G	Comprehensive reproductive health and HIV prevention education using films, role-plays, lectures	6 w, 1 session /w for 2-6 hr	PHY	NR	6m	
(102)	Figueroa	2016	Mozambique	Post-only	Adults	Comm	915	NR	Community dialogue and video	G	A program to address underlying social determinants, especially inequitable gender norms, as a fundamental step in reducing HIV risk behaviors, increasing self-efficacy to talk about and address HIV, and decreasing HIV stigma through community discussions	10w, 1 session /w	FAC	No cont.	NR	
(127)	Futterman	2010	South Africa	N-rct	Women	Obstetric unit and health centre	71	16-42	Peer mentoring, Behavioural, PMTCT	G	An intervention to educate HIV+ mothers about PMTCT and to provide support through mentor mothers	NR	PE	Standard prenatal support	6m	
(117)	Geibel	2012	Kenya	Pre-Post	Male sex workers	Comm	442	21-27	Peer counseling	I	A drop-in centre-based HIV counseling, referral and condom distribution program	NA	PE	None	NA	NA

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(109)	Gregson	2007	Zimbabwe	RCT	General Population	Comm	9454	NR	Peer education, income generation and clinic-based treatment and counselling	I	A program of condom distribution, STI management, HIV/AIDS educational activities and safe sex promotion	NR	PE	Standard services (including STI management)	NR	
(128)	Harvey	2000	South Africa	RCT	Adolescents &Young Adults	School	1080	13-29	Drama-based	G	A drama-in-education HIV prevention intervention	NR	TE, AC, N	Written information about HIV/AIDS	6m	
(95)	Hawk	2013	USA	Group-RCT	Women	Comm	149	18-65	Party-based risk reduction	G	A community based risk reduction intervention and HIV testing program, based on HIV information dissemination at parties	NR	FAC	DI	3m	
(87)	Jemmott	2015	South Africa	Cluster-RCT	Adolescents &Young Adults	School	1057	NR	Role-play, group discussions based	G	A school based HIV prevention intervention using role playing, discussions and group exercises	1 w, 6 2-hr sessions	NR	GH	3m	54 m
(129)	Jemmott	1992	USA	RCT	Adolescents &Young Adults	Outpatient clinic	157	NR	Video and game-based	G	An AIDS risk reduction intervention	5hr, one-time	FAC	Career opportunities intervention	Imm	3m
(108)	Jewkes	2008	South Africa	Cluster-RCT	Adolescents &Young Adults	Comm	2776	15-26	Participatory leaning	G	A HIV prevention intervention to improve sexual health by using participatory learning approaches to build knowledge, risk awareness, and communication skills	50hrs	PS	Standard HIV prevention	12m	24 m

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(93)	Kaponda	2011	Malawi	Q-rct	Adults	Comm	1152	NR	Peer education	G	A peer group intervention for HIV prevention aiming to foster skill building and social support among the group. Content was shaped by collaboration with local health centres	6 2hr sessions	PE	DI	6m	18 m
(86)	Klein	2011	USA	RCT	Female Adolescents &Young Adults	Comm	178	14-19	Computer-based	I	A computer based individual HIV prevention intervention	2hr, one-time	PE	GH	3m	
(94)	Klein	2013	USA	RCT	Women	AIDS service organizations	175	18-50	Computer-based	I	A computer based individual HIV prevention intervention	2hr, one-time	FAC	brief HIV prevention discussion at an AIDS organization	3m	
(115)	Klinger	2016	Madagascar	Pre-Post	Adolescents &Young Adults	School	155	15-19	Educational	G	A complimentary teaching methods intervention for HIV and STI prevention and reproductive health	6 sessions, 1.5hrs each	NR	No cont.	Imm	
(99)	Kuhn	1994	South Africa	Q-rct	Adolescents &Young Adults	School	567	12-30	Educational, active comm. participation	G	An educational HIV program designed and implemented through community participation	2 w	TE	None	Imm	
(118)	Leonard	2000	Senegal	Pre-Post	Truckers	Transportation parks	260	13-70	Peer education	G	A peer education program on condom use, HIV transmission and prevention by and for transport workers	NR	PE	No cont.	3m	
(113)	Manafa	2006	Nigeria	Pre-Post	Adults	Comm	6000	18-70	Mass media intervention	M	A mass educational campaign consisting of rallies, radio, tv and newspaper messages and workshops for teachers	NR	TE	No cont.	3m	

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(116)	Masham ba	2011	South Africa	Q-rct	Faith healers	Church	103	NR	Educational	G	An educational intervention on HIV and other infectious diseases, targeted at faith healers (so that they can pass information on to their congregation)	2 d	NR	Information booklet only	2m	
(130)	Michiels en	2012	Rwanda	N-RCT	Adolescents &Young Adults	School	1950	NR	Peer education and participatory learning	G, I	A peer-led intervention using group and individual counselling, drama performances, songs and other interactive methods.	14 m	TE, PE	None	6m	12 m
(122)	Miller	2008	Kenya	Pre-Post	Adolescents &Young Adults	College /Uni	632	NR	Peer education (ABC-based)	G	An ABC based peer education intervention for HIV prevention	2 y	PE	No cont.	24m	
(100)	Munoda wafa	1995	Zimbabw e	Q-rct	Adolescents &Young Adults	School	285	NR	Educational	G	A health education intervention provided by nursing students (focusing on HIV/AIDS and other health issues)	7 w	NS	None	Imm	
(131)	Muyinda	2003	Uganda	RCT	Female Adolescents &Young Adults	Comm	95	NR	Senga-based	G, I	An intervention training Sengas (paternal aunts) to provide HIV and sexual health information to girls in rural Uganda	12 m	Senga s	None	6m	12 m
(112)	Ndebele	2012	South Africa	Pre-Post	Adolescents &Young Adults	School	130	14-19	Educational	G	An educational intervention on HIV and sexual health held at regular school orientation classes	3 w, 3 45 min session s /w	AU	DI	1m	
(119)	Ofotokun	2010	Nigeria	RCT	General Population	Comm	1205	NR	Audio intervention, educational	G	A Culturally-adapted and audio-technology assisted HIV/AIDS awareness and education program	1d, one-time	CC	Seminar-based HIV education	7w	

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(97)	Osagbemi	2007	Nigeria	Q-rct	General Population	Comm	1029	12-60	Peer education, drama	G	An intervention to address the cultural norm of spouse sharing and its role in the spread of HIV, involving drama, posters, and peer education	NR	PE	None	13m	
(132)	Pronyk	2008	South Africa	RCT	Female Adolescents &Young Adults	Comm	220	14-35	Microcredit and HIV education	G	Group-based microfinance program plus HIV and gender equality training	1 y, 1 session every 2 w	FAC	NR	2y	
(133)	Ross	2006	Nigeria	RCT	Military personnel	Military bases	2209	NR	Risk situation focused (role plays, discussions)	I	An individually focused intervention emphasising risk behaviour reduction	5 modules	HE	DI	6m	12 m
(89)	Sales	2010	USA	RCT	Female Adolescents &Young Adults	Community health centres	245	NR	Educational and skills-based	G	An intervention emphasizing HIV knowledge and condom use skills	Four 4hr sessions	HE	GH	6m	12 m
(105)	Sapiano	2013	USA	Pre-Post	Female Adolescents &Young Adults	Community-based organizations	498	18-62	Educational	G	a culturally relevant and gender-specific, five-session, group level, HIV prevention intervention	5 sessions, 2hrs each	FAC	No cont.	90d	180 d
(111)	Srinivas	2013	South Africa	Pre-Post	School children	School	432	NR	Computer-based, board game-based	G	An HIV intervention using computer quizzes and board games, adapted to children's ages	NR	NR	No cont.	NR	
(120)	Talbot	2013	Rwanda	Pre-Post	Adolescents &Young Adults	NGO	120	15-25	Integrated mental health intervention	G, I	An intervention for orphans, integrating both mental health services and HIV prevention	1 y	PS	No cont.	12m	

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
(124)	Temmerman	1990	Kenya	matched control	HIV+ Mothers	Maternity wards	1507	NR	Nurse counseling	I	HIV+ mothers were counselled by trained nurses regarding reproductive behaviour	one-time	N	None	NR	
(101)	Terry	2006	Zimbabwe	quasi-experimental	Adolescents &Young Adults	College /Uni	869	NR	Educational	G	An NGO-run health promotion and HIV prevention program	various programs	NR	None	Ongoing	
(134)	Villar-Loubet	2013	South Africa	RCT	Pregnant couples	Community health centres	478 (239 couples)	18-53	Behavioural	C	A behavioural HIV risk reduction intervention for pregnant couples in addtion to standard prenatal care	1 m	NR	Usual prenatal care plus health education	Imm	4-5m
(123)	Visser	2005	South Africa	Pre-Post	School children	School	667	NR	Life skills based	G	The intervention involves dissemination of information, development of cognitive and behavioural skills and aims at changing social norms related to sexual behaviour among young people.	2 y	TE	No cont.	NR	
(107)	Wagman	2015	Uganda	Cluster-RCT	General Population	Comm	11 448	15-49	Integrated Intimate partner violence prevention	M	standard of care HIV services plus a community-level mobilisation intervention to change attitudes, social norms, and behaviours related to IPV, and a screening and brief intervention to promote safe HIV disclosure and risk reduction	4 y	PS	only standard of care HIV services	16m	35 m
(88)	Wilson	2014	USA	Pre-Post	Men	Barbershops	80	18–43	Barbershop-based	G	community-based HIV prevention program that seeks to improve individual skills and motivation to decrease sexual risk, and that builds men's interest in and capacity for	2 hrs, one-time	Barbers	No cont.	3m	

Ref	First Author	Year	Study Country	Study Design	Target Population	Study Setting	Total N	Age range	Type of HIV Knowledge intervention and method of dissemination		Intervention Description	L&F	Prov.	Ctrl	FU 1	FU 2
											improving their community's health					
(90)	Wingood	2006	USA	RCT	Female Adolescents &Young Adults	Comm unity health centres	146	14-18	Educational (gender violence perspective)	G	HIV prevention intervention emphasising ethnic and gender pride, HIV knowledge, condom attitudes, healthy relationships, communication, and condom use skills.	4 session s, 4hrs each over 4w	NR	GH	3m	6m
(77)	Wingood	2013	South Africa	RCT	Women	Health clinics	342	18 – 35	Peer education	G	A culturally adapted intervention addressing HIV stigma and prevention	3 2.5hr session s	PE	GH	6m	
(135)	Yoder	1996	Zambia	Q-rct	General Population	Comm	1600	NR	Radio drama broadcast	M	A national radio drama about HIV prevention	9 m	NA	low radio access group	Imm	

AC: Actors
AU: Authors
C: Couple
Comm.: Community
Ctrl: Control group treatment
d: day(s)
DI: Delayed intervention
FAC: Facilitators
FU1&2: Follow-up time 1&2
G: Group
GH: General health intervention
GS: Graduate students
HE: Health educators
I: Individual
Imm: Immediate
L&F: Length and frequency of intervention
LIB: Librarians
M: Mass / community campaign
m: month
N: Nurses
N-RCT: non-RCT
NS: Nursing Students
PE: Peer educators
PHY: Physicians
Prov.: Providers of intervention
PS: Program Staff
Q-RCT: Quasi-RCT
RCT: Randomized Controlled Trial
TE: Teachers
TRA: Trainers

(a) no cont. = study had no control
(b) none = no treatment

Appendix 6.3. Types and Components of Interventions Implemented in the Included Studies

Study (Ref, Author, Year)		Intervention Type / Components																		
		Audio	Behaviour change	Community education	Computer-based	Skills-based	Board game or other games	Drama	Educational / informational	Microcredit	Integrated psychosocial intervention	Mass media campaign	Motivational and Behavioural	Peer education	PMTCT	Faith-based	Radio	Scenarios / situational / role plays	Video	Others
(104) Abu-Saeed	2013													■						
(98) Adeomi	2014													■						
(110) Ajuwon	2013			■																
(103) Baldwin	2008													■		■				
(126) Billings	2015		■																	
(106) Bing	2008												■							
(85) Card	2011				■															
(84) Cornelius	2013																			Text messaging
(114) Fawole	1999																	■	■	
(102) Figueroa	2016																		■	
(127) Futterman	2010		■											■	■					
(117) Geibel	2012													■						
(109) Gregson	2007													■						
(128) Harvey	2000							■												
(95) Hawk	2013																			Party-based
(87) Jemmott	2015																	■		
(129) Jemmott	1992						■												■	

Study (Ref, Author, Year)		Intervention Type / Components																		
		Audio	Behaviour change	Community education	Computer-based	Skills-based	Board game or other games	Drama	Educational / informational	Microcredit	Integrated psychosocial intervention	Mass media campaign	Motivational and Behavioural	Peer education	PMTCT	Faith-based	Radio	Scenarios / situational / role plays	Video	Others
(108) Jewkes	2008																			Participatory learning
(93) Kaponda	2011													■						
(86) Klein	2011				■															
(94) Klein	2013				■															
(115) Klinger	2016								■											
(99) Kuhn	1994			■																
(118) Leonard	2000													■						
(113) Manafa	2006											■								
(116) Mashamba	2011								■											
(130) Michielsen	2012													■						
(122) Miller	2008													■						
(100) Munodawafa	1995								■											
(131) Muyinda	2003																			"Senga"-based (a)
(112) Ndebele	2012								■											
(119) Ofotokun	2010	■																		
(97) Osagbemi	2007							■						■						
(132) Pronyk	2008								■	■										

Study (Ref, Author, Year)		Intervention Type / Components																		
		Audio	Behaviour change	Community education	Computer-based	Skills-based	Board game or other games	Drama	Educational / informational	Microcredit	Integrated psychosocial intervention	Mass media campaign	Motivational and Behavioural	Peer education	PMTCT	Faith-based	Radio	Scenarios / situational / role plays	Video	Others
(133) Ross	2006								■									■		
(89) Sales	2010					■			■											
(105) Sapiano	2013								■											
(111) Srinivas	2013				■															
(120) Talbot	2013										(b)									
(124) Temmerman	1990																			Nurse-led counselling
(101) Terry	2006								■											
(134) Villar-Loubet	2013		■																	
(123) Visser	2005					■														
(107) Wagman	2015										(c)									
(88) Wilson	2014																			Barbershop-based
(90) Wingood	2006								(d)											
(77) Wingood	2013													■						
(135) Yoder	1996																■			

Blacked-out fields indicate components part of each intervention.
PMTCT = Prevention of Mother-to-Child Transmission

(a) “Senga” is the Ugandan term for a father's sister, and this intervention was based on the traditional Ugandan societal concept that a young female's paternal sister is considered her main source of information regarding marriage and sexual relationships

(b) Integrated mental health intervention (c) Integrated intimate partner violence intervention (d) Included a gender violence perspective

Appendix 6.4. Intervention Effects on Mean Condom Use

Study (Ref, Year)	Study Country	Int type	Sample Size (N)					P value type [a]	Measure / definition of condom use	Time Frame	Condom Use (Mean, SD)									
			Total	int	cont	int fu	cont fu				Int bsl	SD	int fu	SD	p value	Cont bsl	SD	Cont fu	SD	p value
(94) 2013	USA	Comp	175	87	88	81	87	I	Number of unprotected vaginal and anal sex acts	30d	1.4	2.7	0.24	0.54	0.28	1.3	3.4	3	6.18	0.02
(105) 2013	USA	Ed	498	498		401 fu2: 394		P	Number of unprotected sex events	NR	11.8	19.6	6.5 fu2: 6.4	11.1 fu2: 11.8	ns (bsl)					<0.001 fu2: <0.001
(90) 2006	USA	Ed	146	73	73	63 fu2: 61	65 fu2: 65	I	Number of unprotected sex acts	6m	7.34	17.18	5.89 fu2: 6.20	14.84 fu2: 14.16	0.69 bsl	6.32	11.15	17.50 fu2: 17.51	38.54 fu2: 36.74	0.008
(106) 2008	Angola	Motiv / BC	568	280	288	NR	NR	NA	Number of unprotected vaginal sex acts with girlfriends	3m	2.1	4.6	1.2 fu2: 1.6	2.5 fu2: 4.0		2.2	4.8	2.0 fu2: 1.8	4.5 fu2: 4.7	
(106) 2008	Angola	Motiv / BC	568	280	288	NR	NR	NA	Number of unprotected vaginal sex acts with occasional partners	3m	0.5	1.7	0.2 fu2: 0.1	1.2 fu2: 0.9		0.7	2.6	0.4 fu2: 0.2	2.4 fu2: 1.0	

(106) 2008	Angola	Motiv / BC	568	280	288	NR	NR	NA	Number of unprotected vaginal sex acts with commercial partners	3m	0.2	1.2	0.1 fu2: 0.04	0.6 fu2: 0.4		0.2	2	0.04 fu2: 0.2	0.4 fu2: 1.8	
(77) 2013	South Africa	PE	342	175	167	121	120	I	Number of unprotected vaginal sex acts	3m	6.92	10.03	4.01	0.9	0.73	6.52	11.08	6.57	0.94	0.05 (fu int vs cont)
(129) 1992	USA	Scenario	157	85	72	85 fu2: 58	71 fu2: 48	NA	Number of days respondents did not use a condom during sex	3m	NR	NR	NR fu2: 0.64	NR fu2: NR		NR	NR	NR fu2: 2.38	NR fu2: NR	
(95) 2013	USA	Party	149	36	55	36	55	NA	Number of vaginal sex acts without a condom	NR	7.86	12.59	6.47	7.91		4.44	7.41	5.58	13.17	

BC = Behaviour change
Bsl = baseline
Comp = Computer-based
Cont = Control
Ed = Educational / informational
Fu = Follow-up
Int = Intervention
MM = Mass Media
Motiv = Motivational
NR = Not reported
PE = Peer education
Scenario = scenario-based/ role-play based

[a] P value type I= Int. vs. control, P = Pre- vs. Post-test. Where two p values are available, Int. vs. cont p values: 1st p value =Int, 2nd=Control. Pre-Post p values: 1st p value=pre-test, 2nd = post-test.

Appendix 6.5. Intervention Effects on Proportion of Participants Using Condoms

Study (Ref, Year)	Study Country	Int type	Sample Size (N)					P value type [c]	Measure / definition of condom use	Proportion of Condom use (N of respondents or N sex acts, as specified)							
			Total	int bsl [a]	cont bsl	int fu	cont fu			int bsl	int fu	SD	P value	cont bsl	cont fu	SD	P value
(126) 2015	USA	BC	83	45	38	34 fu2: 39	34 fu2: 34	NA	Proportion of protected sex acts over time interval (% of acts)	44.2%	72.1% fu2: 59.5%		NR	39.10%	41.8% fu2: 31.7%		NR
(134) 2013	South Africa	BC	159	[b]				P	Consistent condom use in the past 7 days	27%	60% fu2: 43%		0.9	21%	20% fu2: 33%		0.95
(85) 2011	USA	Comp	135	67	68	58	58	I	Proportion of condom protected sex acts	NR	85.3%	10.1	NR	NR	52.8%	9.5	<0.03
(86) 2011	USA	Comp	178	21	17	21	17	P	Proportion of vaginal sex acts with condoms in past 3 months	0.51	0.71 fu2: 0.05			0.72	0.57		0.12
(116) 2011	South Africa	Ed	103	58	45	58	45	NA	Any condom use (unspecified period)	36	40		NR	40	42		NR
(122) 2008	Kenya	Ed	632	632		746		P	Ever used a condom (of those who have ever had sex)	77%	86%		<0.001				
(122) 2008	Kenya	Ed	632	632		746		P	Used a condom every time had sex in previous month	40%	45%		<0.05				
(101) 2006	Zimbabwe	Ed	869	NR	NR	251	618	I	Used a condom at last sex (of those who have ever had sex, n=191 int and n=512 cont	NR	56		ns	NR	182		
(90) 2006	USA	Ed	146	73	73	63 fu2: 61	65 fu2: 65	I	Consistent condom use in past 30 days	42	61.3% fu2: 72.6%		0.96 bsl	41	38.3% fu2: 48.9%		0.01
(132) 2008	South Africa	Ed / micro	220	60	59	51	45	NA	Unprotected sex with a non-spousal partner in the past 12 months	40	28		NR	47	35		NR
(89) 2010	USA	Ed / skills	245	126	119	111 fu2: 109	103 fu2: 104	I	Consistent condom use past 6 months	57	64 fu2: 59		NR	60	36 fu2: 45		0.004 fu2: 0.262

(120) 2013	Rwanda	IMH	120	120		120		P	Use of condoms when engaged in high-risk sexual behaviour	65	94	NR				
(107) 2015	Uganda	IPV	11448.00	5337	6111	2282 fu2: 931	2362 fu2: 1170	I	Condom use in past year (female data)	NR	216 fu2: 157		NR	201 fu2: 192		
(107) 2015	Uganda	IPV	11448.00	5337	6111	1408 fu2: 601	1613 fu2: 806	I	Condom use in past year (male data)		216 fu2: 153			217 fu2: 188		
(113) 2006	Nigeria	MM	6000	6000		NR		NA	Use condoms during sex	38.4%	46.9%					
(104) 2013	Nigeria	PE	160	80	80	80	80	I	Always use a condom (n)	5	12		2	2		NR
(117) 2012	Kenya	PE	442			145	297	I	Always used a condom with clients in past 30 days		90			132		
(117) 2012	Kenya	PE	205			80	125	I	Always used a condom with non-paying clients in the past 30 days		37			44		
(93) 2011	Malawi	PE	1152	629	523	180 fu2: 415	176 fu2: 413	I	Ever used a condom in the past 2 months	NR	36 fu2: 77	<0.01	NR	13 fu2: 40		<0.01
(118) 2000	Senegal	PE	260	48		48		P	Always uses a condom with regular partners	25	42	NR				
(127) 2010	South Africa	PE / BC / MTC	71	40	31	40	31	NA	Always use a condom or abstaining	NR	38		NR	30		
(97) 2007	Nigeria	PE / drama	1029	591	438	588	430	P	Any condom use	18	48	<0.001	14	17		NR
(130) 2012	Rwanda	PE / PL	1950	186	124	135 fu2: 133	109 fu2: 108	NA	Used condom at last sex (of those sexually active)	83	55 fu2: 63	NR	47	45 fu2: 44		NR
(133) 2006	Nigeria	scenario	2209	1222	987	825 fu2: 884	811 fu2: 875	NA	vaginal or anal sx without condoms with a casual partner in the past 6 weeks	1081	507 fu2: 601	NR	908	743 fu2: 840		NR
(123) 2005	South Africa	Skills	667	33		43		P	No condom use at last sex	33	36	0.03				

(84) 2013	USA	TM	40	40		36 fu2: 36		P	Number of reported unprotected sex acts	31	19 fu2: 9		0.328				
(87) 2015	South Africa	Self-E	1056	561	495	543 fu2: 519	485 fu2: 455	NA	Any unprotected vaginal intercourse in the past 3 months	4	9 fu2: 132		NR	3	20 fu2: 126		NR
(114) 1999	Nigeria	Video / scenario	450	233	217	223	210	NA	Always use a condom		11	NR			10	NR	
(88) 2014	USA	Barber	80	80		71		P	Having any unprotected sex in the past 3 months	75%	58.6%		<0.007				
(88) 2014	USA	Barber	80	80		71		P	Having unprotected sex with two or more women in the past 3 months	46%	17%		<0.0001				
(128) 2000	South Africa	Drama	1080	487	576	298	380	NA	Ever used a condom (of those who have had sex)	165	129		NR	193	188		NR
(124) 1990	Kenya	NC	1507	94	1413	24	33	I	Any condom use	NR	2		ns	NR	2		
(108) 2008	South Africa	PL	2776	1409	1367	1063 fu2: 1005	1006 fu2: 994	I									
(135) 1996	Zambia	Radio	1600	314	407	374	412	P	Ever used a condom (male data)	49.7%	50.5%		NR	29%	36.4%		<0.05
(135) 1996	Zambia	Radio	1600	278	530	267	548	P	Ever used a condom (female data)	20.8%	27.0%		NR	10.9%	20.3%		<0.001
(131) 2003	Uganda	Senga [d]	95	26	11	26 fu2: 26	11 fu2: 11	NA	Consistent condom use (of sexually active sample)	13	14 fu2: 19		NR	5	6 fu2: 6		NR

BC = Behaviour change
Bsl = baseline
CE = Community Education
Comp = Computer-based
Cont = Control
Ed = Educational / informational
Fu = Follow-up
IMH = integrated mental health intervention
Int = Intervention
IPV = integrated intimate partner violence intervention
Micro = Microcredit loans
MM = Mass Media
MTC = Mother-to-Child Transmission Prevention
NC = Nurse counselling
NR = Not reported
PE = Peer education
PL = Participatory Learning
Scenario = scenario-based /role-play based
Self-E = Self-efficacy based
Skills = Skill-building based
TM = Text messaging

[a] Only N values for the sexually active subsamples relevant to condom use outcomes are reported for all treatment arm sample sizes here.
[b] N for treatment arms unclear for this outcome, as sexually active proportion is not reported.
[c] P value type I= Int. vs. control, P = Pre- vs. Post-test. Where two p values are available, Int. vs. cont p values: 1st p value =Int, 2nd=Control. Pre-Post p values: 1st p value=pre-test, 2nd = post-test.
[d] "Senga" is the Ugandan term for a father's sister, and this intervention was based on the traditional Ugandan societal concept that a young female's paternal sister is considered her main source of information regarding marriage and sexual relationships

Appendix 6.6. Risk scores across criteria for each RCT and N-RCT study (assessed via the Cochrane Risk of Bias Tool).

Risk of Bias Level:

Low	Unclear	High

First Author	Year	Study Design	Risk of Bias Criteria								
			Random Sequence Generation	Allocation Concealment	Baseline Characteristics Similar (control vs intervention group)	Blinding of participants and personnel	Blinding of Outcome Assessors	Contamination	Attrition bias (incomplete outcome data)	Reporting bias (Selective outcome reporting)	Other Sources of Bias (Funding, COIs)
Jemmott	2015	Cluster-RCT									
Jewkes	2008	Cluster-RCT									
Wagman	2015	Cluster-RCT									
Hawk	2013	Group-RCT									
Card	2011	Q-rct									
Fawole	1999	Q-rct									
Kaponda	2011	Q-rct									
Kuhn	1994	Q-rct									
Mashamba	2011	Q-rct									
Munodawafa	1995	Q-rct									
Osagbemi	2007	Q-rct									
Yoder	1996	Q-rct									
Abu-Saeed	2013	RCT									
Adeomi	2014	RCT									

Billings	2015	RCT										
Bing	2008	RCT										
Gregson	2007	RCT										
Harvey	2000	RCT										
Jemmott	1992	RCT										
Klein	2011	RCT										
Klein	2013	RCT										
Muyinda	2003	RCT										
Ofotokun	2010	RCT										
Pronyk	2008	RCT										
Ross	2006	RCT										
Sales	2010	RCT										
Villar-Loubet	2013	RCT										
Wingood	2006	RCT										
Figueroa	2016	RCT										
Wingood	2013	RCT										
Baldwin	2008	N-rct										
Futterman	2010	N-rct										
Michielsen	2012	N-rct										
Terry	2006	Quasi-experimental										

Appendix 6.7. Component criteria of total risk scores for pre-post and other uncontrolled studies (assessed via the Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control).

First Author	Year	Objective Clearly Stated	Eligibility criteria for participants pre-specified and clear	Participants representative of the general population of interest	Unbiased enrollment of all eligible participants	Sample size sufficient (confirmed by power calculation)	Intervention clearly described and consistently delivered to all participants	Outcomes pre-specified and consistently measured	Blinding of outcome assessors	Loss to follow-up less than 20% or accounted for in the analysis	Statistical methods appropriate to detect changes before to after	Multiple before and after measures	Total Score, out of 11 [a] (% score)	Final Risk Level [b]
Ajuwon	2013	1	0	1	0	0	1	1	0	1	1	0	6 (54.55)	M
Cornelius	2013	1	1	1	1	0	1	1	0	1	1	0	8 (72.73)	M
Klinger	2016	1	1	1	1	0	1	1	0	1	1	0	8 (72.73)	M
Leonard	2000	1	1	1	1	0	1	1	0	1	1	0	8 (72.73)	M
Manafa	2006	1	0	1	1	0	1	1	0	0	1	0	6 (54.55)	M
Miller	2008	1	1	1	1	0	1	1	0	0	1	0	7 (63.64)	M
Ndebele	2012	1	1	0	1	1	1	1	0	0	1	0	7 (63.64)	M
Sapiano	2013	1	1	1	1	1	1	1	0	0	1	0	8 (72.73)	M
Srinivas	2013	1	0	0	1	0	1	1	0	0	1	0	5 (45.45)	M
Talbot	2013	1	1	1	1	0	1	1	0	0	1	0	7 (63.64)	M
Visser	2005	1	0	1	0	0	1	1	0	0	1	0	5 (45.45)	M
Wilson	2014	1	1	1	1	0	1	1	0	1	1	0	8 (72.73)	M
Temmerman	1990	1	1	0	1	0	1	1	0	0	1	0	6 (54.55)	M
Geibel	2012	1	1	0	1	0	1	1	0	1	1	0	7 (63.64)	M

[a] One of the original tool's criteria; "in the case of group-level interventions, adjustments made for use of individual data to determine group level effects", was not relevant to any of the included studies, and, as recommended by the tool developers, was thus not included in the assessment.

[b] 0-25% = high risk, 26-75% = moderate risk (M), 76-100% = low risk

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