AN EXPANDED HIV RESPONSE TO OPTIMIZE OUTCOMES FOR EXPOSED INFANTS IN KASUNGU DISTRICT, MALAWI

ELTON CHIMWEMWE CHAVURA

A THESIS SUBMITTED TO THE DEPARTMENT OF WATER AND SANITATION

FACULTY OF ENVIRONMENTAL SCIENCE

MZUZU UNIVERSITY

IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE

DEGREE OF DOCTOR OF PHILOSOPHY IN SANITATION

JULY 2024

AN EXPANDED HIV RESPONSE TO OPTIMIZE OUTCOMES FOR EXPOSED INFANTS IN KASUNGU DISTRICT, MALAWI

ELTON CHIMWEMWE CHAVURA

MSc Public Health (MPH), MSc (Sanitation), BSc (Public Health),

Dip (Clinical Anesthesia & Intensive Care Medicine), Certificate (Clinical Medicine)

A THESIS SUBMITTED TO THE DEPARTMENT OF WATER AND SANITATION, FACULTY OF ENVIRONMENTAL SCIENCE IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN SANITATION

DECLARATION

I hereby declare that this Thesis titled, *"An expanded HIV response to optimize outcomes for exposed infants in Kasungu District, Malawi"* has been written by me and is a record of my research work. All citations, references, and borrowed ideas have been duly acknowledged by means of references. It is being submitted in fulfilment of the requirements for the award of the degree of **Doctor of Philosophy (Ph.D) in Sanitation** of the Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University. Parts of the materials presented in this thesis have been submitted for publication or have been published and appear as:

- Chavura E., Singini W., Chidya R. & Mbakaya B.C. (2023). Combined Effect of Cotrimoxazole Prophylaxis and Safe Water on Diarrhoea amongst HIV-Exposed Infants and People Living with HIV/AIDS: A Systematic Review European Scientific Journal, ESJ, 19 (9), 20. https://doi.org/10.19044/esj.2023.v19n9p20
- Chavura E., Singini W., Chidya R. & Mbakaya B.C. (2022). The Effect of Improved Water, Sanitation and Hygiene on Linear Growth Amongst Children Living in Developing Countries: A Systematic Review. European Scientific Journal, ESJ, 18 (30), 296. https://doi.org/10.19044/esj.2022.v18n30p296
- Chavura E., Singini W. Chidya R. & Mbakaya B.C. (2023). Immunological Responses to Helminths and HIV-1 Co-Infections. European Scientific Journal, ESJ, 19 (9), 211. https://doi.org/10.19044/esj.2023.v19n9p211

ELTON CHAVURA 30 June 2024

_____ _____

Student's name Date

CERTIFICATE OF COMPLETION

I, the undersigned, certify that this thesis is a result of the author's own work, and that to the best of my knowledge, it has not been submitted for any other academic qualification within the Mzuzu University or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on 24th July 2024

_____ _____

Major Supervisor: Date

Name: Professor Wales Singini (Ph.D)

_____ _____

Co-Supervisor: Date

Name: Dr Russel Chidya (Ph.D)

_____ 29th July 2024

Co-Supervisor: Date

Name: Associate Professor Balwalani Chingatichifwe Mbakaya (Ph.D)

_____ _____

Post Graduate Coordinator: Date

Name: Dr Russel Chidya (Ph.D)

_____ _____

Head of Department: Date

Name: Dr Brighton Chunga (Ph.D)

ABSTRACT

Benefits of water, sanitation, and hygiene (WaSH) extend well beyond the risk of diarrhoea. They include reduction in the risk of malnutrition, helminth infections and disproportionate adverse effects due to suppressed immune systems. The study evaluated the potential contribution of WaSH towards three outcomes: diarrhoea, linear growth trajectory and disease progression among HIV-Exposed Infants (HEI). A quantitative cross-sectional study was conducted in Kasungu, Malawi. The first study participant was randomly selected. However, next, every study participant was selected in the order of every Kth interval (rounded to 3) until the final sample size of 293 was reached. The methodologies of systematic reviews were appraised using a Mixed Method Appraisal Tool (MMAT). Marital status ($p = 0.021$), level of education ($p = 0.001$) and employment ($p = 0.024$) had significant influence on diarrhoea. WaSH and co-trimoxazole together reduced diarrhoea episodes by up to 67% (IRR _ 0.33, 95% CI 0.24–0.46, $p < 0.0001$). No difference in mean height for age z-score (0.01, 95% CI-0.16 to 0.18) between children who had access to WaSH and those without it. Plasma Viral load (VL) was significantly higher among helminths-infected than the non-infected group (5.01 log10 vs. 3.41 log10, $p < 0.001$). CD4+ T-lymphocyte count values were not significantly different in the co-infection group relative to those with HIV-infection alone. Besides the on-going use of cotrimoxazole prophylaxis, improved WaSH among HEI could be a cost-effective and sustainable intervention for the prevention of diarrhoea and remedy for slowing down the progression of the sub-clinical disease to symptomatic AIDS; but has inconsistent effects on linear growth trajectory. Given the dreadful state of living conditions among most HEI, biomedical interventions alone though necessary, are insufficient and narrow in scope. An expanded WaSH/HIV response, to address exposed infants' vulnerability, therefore, offers them a more pragmatic recourse.

Key words: *Water, sanitation and hygiene, HIV-Exposed Infant, Helminths, Cotrimoxazole*

DEDICATION

To my dear and beloved father

(Elton Lameck Wandionera Gulingwachi Mbwangandu Chavura):

You will always be remembered as the greatest source of inspiration.

Only put off until tomorrow what you are willing to die having left undone!

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to my research supervisors Professor Wales Singini and Dr Russel Chidya for their tireless efforts towards the success of this project. I wouldn't be able to get my work done without the continual support and vision of my mentor Associate Professor Balwani Mbakaya Chingatichifwe. You gave me strength and encouragement to move on when I couldn't.

All my close friends and family for the patience and profound belief in me. To my wife Mwai, for putting up with me being sat in the office for hours on end, and for sacrificing family resources and psychological comfort when I was in need. I am forever grateful for your commitment to the project and continuous motivation. I'd like to acknowledge the assistance of the Head of Department, Dr Brighton Chunga, Mr Swithern Matamula, Mr Itai Zuze, Mr Eddie Mtonga, Mr Madalitso Mngombe, Mr Ngagne Ndong, Mr Tirivanhu Tizifa and Mr Gideon Nyasulu for all your practical suggestions towards the success of this project.

I am also particularly thankful to all my PhD classmates (class of 2019) for their unparalleled knowledge and lecturers in the Faculty of Environmental Sciences at Mzuzu University and (MPH classmates and staff) Swansea University, Faculty of Medicine, Health and Life Science, Wales, United Kingdom for the taught lessons and numerous seminars that uplifted my thesis writing skills. I am forever grateful for their invaluable contribution. To all the research participants, who sacrificed time, your patience cannot be underestimated. I hope that the outcome of this study will someday assist you in so many ways.

>The King will reply, "Truly I tell you, whatever you did for one of the least of these brothers and sisters of mine, you did for me" Matthew 25:40

ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome 2
ANOVA	Analysis of Variance
ART	Antiretroviral Therapy
ARVs	Antiretrovirals
CD4	Cluster of Differentiation 4
DNA	Deoxyribonucleic Acid
EMTC	Elimination of Mother To Child Transmission
HEI	HIV Exposed Infant
HIV	Human Immunodeficiency Virus
HUEI	HIV Unexposed Infant
HMIS	Health Management Information System
ILO	International Labour Organization
MDHS	Malawi Demographic Health Survey
NTD	Neglected Tropical Diseases
PLWHA	People Living With HIV and AIDS
PMTCT	Prevention of Mother to Child Transmission
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
WaSH	Water, Sanitation and Hygiene
WHO	World Health Organization

TABLE OF CONTENTS

DECLARATION II

CERTIFICATE OF COMPLETION III

ABSTRACT IV

DEDICATION VI

ACKNOWLEDGEMENTS VII

LIST OF TABLES XIV

LIST OF FIGURES XV

CHAPTER ONE: INTRODUCTION 1

1.1. Background of the study 1

1.2. Problem Statement 6

1.3. Research Objectives 8

1.3.1. Main Objective 8

1.3.2. Specific Objectives 8

1.3.3. Research Hypothesis 8

1.4. Significance of the study 9

1.5. Ethical consideration 10

CHAPTER TWO: LITERATURE REVIEW 11

2.1.The Conceptual Framework 11

2.2.Legislation of WaSH Services in Malawi 17

2.3.Alignment of the Local HIV Policies to International Guidelines 19

2.4.Co-trimoxazole Prophylaxis- Rationale and Recommendations for Usage 21

2.5.Theoretical Framework 23

2.6.The influence of WaSH descriptors on diarrhoea 26

2.7.Added effect of co-trimoxazole prophylaxis and safe water on diarrheoa 32

2.8. The effect of improved WaSH on linear growth 33

2.9. The effect of helminths infections on HIV disease progression among helminth-HIV-1 co-infected persons 35

2.7. WaSH, HIV and Poverty Complex Linkages 39

CHAPTER THREE: MATERIALS AND METHODS 41

3.1. Description of the Study Area 41

3.2. Research design 44

OBJECTIVE 3: The added effect of co-trimoxazole prophylaxis and improved WaSH interventions on diarrhea among HEI and PLWHA 51

OBJECTIVE 4: The effect of improved WaSH on linear growth 56

3.3. Sampling framework and methods 67

3.3.1. Sample size 68

3.4. Data Collection 69

3.5. Data Management and Statistical Analysis 69

CHAPTER FOUR: RESULTS 72

4.1. Introduction 72

4.1.1. Effect of socio-demographic characteristics on diarrhoea among HEI 73

4.1.2. The influence of WaSH descriptors on diarrhoea among HEI 75

4.1.3. The influence of WaSH descriptors on diarrhoea among HEI 76

4.1.4. The Context of Poverty Likelihood among HEI 79

Table 15: The Relationship Between Adherence to NVP, CPT and Diarrhoea 81

4.1.4. The effect of improved WaSH on linear growth 87

4.1.5. The effect of helminth infections on HIV disease progression 94

CHAPTER FIVE: DISCUSSION 101

5.1. Overview 101

5.1.1. The effect of socio-demographic characteristics on diarrhoea among HEI 101

5.1.2. The influence of WaSH descriptors on diarrhoea 107

5.1.3. The effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis 115

5.1.4. The effect of improved WaSH on linear growth 117

5.1.5. The effect of helminth infections on HIV disease progression among helminth/HIV-1 co-infected persons 119

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS 122

5.1. Conclusion 122

5.2. Recommendations 123

REFERENCES 127

APPENDIX 152

LIST OF TABLES

Table 1 : The Malawi Schedule of HIV testing for children (Algorithm) 21

Table 2 : JMP ladder for household drinking water services 29

Table 3 : Global Distribution of Different Helminths 37

Table 4 : The Malawi Simple Poverty Scorecard (Schreiner, 2015). 45

Table 5 : Look-up Table to convert scores to poverty likelihood 46

Table 6 : WaSH Descriptors and Characterization (Flores Baquero et al. 2016) 49

Table 7 : WaSH Descriptors and Characterization (Flores Baquero et al. 2016) 50

Table 8 : WaSH Descriptors and Characterization (Flores Baquero et al. 2016) 51

Table 9 : Search Strategy (1) 54

Table 10 : Search strategy (2) 59

Table 11 : Search Strategy (3) 63

Table 12 : Data Collection and Analysis Matrix 65

Table 13 : Socio-demographic influencing factors of diarrhoea among HEI 74

Table 14 : The influence of WaSH Descriptors on diarrhoea 78

Table 15 : The Relationship Between Adherence to NVP, CPT and Diarrhoea 81

Table 16 : Data Extraction Table 1 82

Table 17 : Mixed Method Appraisal Tool (MMAT) 1 85

Table 18 : Data Extraction Table 2 88

Table 19 : Mixed Method Appraisal Tool (MMAT) 2 91

Table 20 : Data Extraction Table 3 95

Table 21 : Mixed Method Appraisal Tool (MMAT) 3 99

LIST OF FIGURES

Figure 1 : The Socio-ecological model of health 6

Figure 2 : The Conceptual Framework 16

Figure 3 : Standard follow-up schedule for HIV-exposed infants 22

Figure 4 : Theoretical Framework 24

Figure 5 : The F-Diagram 27

Figure 6 : Pathogenesis of environmental enteric dysfunction (EED) 35

Figure 7 : Illustrative distribution of helminths in Sub-Saharan Africa 38

Figure 8 : Map of Kasungu Malawi and the sub-Saharan Africa region 43

Figure 9 : The PRISMA Flow diagram (1) 56

Figure 10 : The PRISMA Flow Diagram (2) 60

Figure 11 : The PRISMA Flow Diagram (3) 64

Figure 12 : Schematic Presentation-The inclusion and exclusion criteria 68

Figure 13 : Toilet Location 75

Figure 14 : Sanitary Descriptors and their Frequencies 75

Figure 15 : Handwashing Status 76

Figure 16 : Sanitary Condition of Toilet and Hygiene Practices 76

Figure 17 : Drinking Water Supply and Access 76

Figure 18 : The Poverty Likelihood Index 79

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Access to water and sanitation is a basic human need that ensures personal hygiene and restores human dignity (Luby 2014). The protective effects of access to improved water and sanitation are many, yet many people in developing countries, especially in rural communities, lack the very access to it. For example, water requirements for the adequate care for people living with HIV/AIDS (PLWHA) exceeds the normal consumption rate by 2-5 times (Yallew et al. 2012). This increase in water consumption is because sanitation needs are critical in order to prevent opportunistic infections such as diarrhoea and skin infections and for self-rehydration. PLWHA also need clean water to take their medications including combination Anti-retroviral therapy (cART), without which they risk further infections (Schilling 2018). The lack of access to sufficient quantities and quality of water and basic sanitation can accelerate HIV disease progression. Many life-threatening opportunistic infections are caused by exposure to unsafe water, inadequate sanitation and poor hygiene (Makaudze 2019). Diarrhoea, a very prominent opportunistic infection (O.I.), can occur throughout the course of HIV/AIDS, affects 90% of PLWHA and results in significant morbidity and mortality, especially in HIV-infected children (Monkemuller & Wilcox 2000; Mbakaya et al. 2019). Co-trimoxazole is one of the main biomedical interventions recommended by the World Health Organization (WHO) in the management of HIV-exposed infants (HEI). It has long been part of the standard care for HEI until it is clear that they are uninfected. It is also widely recommended for people with pro2gressing HIV disease hence, co-trimoxazole prophylaxis prevents O.I.s and is a proven biomedical intervention that prolongs the quality of life in resource-limited settings. To reduce the risk of HIV-associated opportunistic infections, WHO recommends that infants exposed to HIV through

breastfeeding receive co-trimoxazole prophylaxis from 6 weeks of age until an age-appropriate HIV test can be used to ascertain the child's infection status after cessation of breastfeeding.

The population of HEI is expanding and reached nearly 15 million in 2017 (Chandna et al. 2020). In Malawi, HIV infected pregnant and breastfeeding women are required to take life-long cART (Option B+) to prevent their babies from acquiring HIV infection. The national guidelines recommend testing infants exposed to HIV at 6 weeks of age using Polymerase Chain Reaction (PCR) of Dried Blood Spots (DBS) for HIV deoxyribonucleic acid (DNA) detection. Since infants' progress to AIDS and death is much faster than adults, early determination of HIV exposure, definitive diagnosis and treatment are critical. To this effect, cART is initiated upon diagnosis of HIV infection in children aged less than 24 months irrespective of their Cluster of Differentiation (CD4+) T-lymphocyte count (WHO, 2012).

The proportion of under-five deaths attributable to HIV in Malawi is estimated at 13% with diarrhoea as the chief complimentary cause of child mortality. When children get infected with HIV, they are at high risk of illness and death (Chihana et al. 2015). Comprehensive care is key to ensuring that they stay healthy and improve quality of life. Good Water, Sanitation and Hygiene (WaSH) practices can make a significant positive impact on child survival. Access to high quality sanitation significantly reduces the odds of child diarrhoea, stunting and mortality (Mallick et al. 2020; Nandi et al. 2017; Kumar & Vollmer 2013). There are clear links between dirty hands, dirty water and infant mortality. Serious consequences have been noted for babies born with HIV, or who acquire it during delivery or breastfeeding (Campbell et al. 2015). Newborn babies are more at risk from preventable infections, such as sepsis, meningitis or tetanus, all of which have strong links to unhygienic conditions, and lack of clean water. To achieve effective prevention of mother to child

transmission of HIV (PMTCT), 'six cleans' must be practiced: *clean hands, a clean delivery surface, a clean perineum, nothing unclean inserted into the vagina, a clean umbilical cord cutting tool and a clean cord tie* (Hoogenboom et al. 2015). There is also a risk to those who assist HIV positive mothers while giving birth, if they are required to handle soiled linen and wash both mother and baby without adequate clean water, soap and gloves. Having no proper sanitation means that there is a vicious cycle of disease and poverty (McFarlane et al. 2014).

Irrespective of funding of HIV program in Malawi under President's Emergency Plan for AIDS Relief (PEPFAR) in procurement of antiretroviral medicines (ARVs), there is persistent diarrhoea experienced by PLWHA linked to poor WaSH practices thus loss of funds, hence the ultimate goal not achieved (Garriga and Foguet 2013). Safe sanitation is fundamental to public health for effective delivery of health care services as it facilitates in the maintenance of optimal health and prevents the contraction and spread of a myriad of diseases. WaSH, health and poverty are irrevocably intertwined. As such, lack of safe water supply and proper sanitation have impact on the health of PLWHA and socioeconomic development (Veiled et al. 2014). Unsafe sanitation disproportionally affects the poor and the most vulnerable groups in society such as HEI (Valentino et al. 2012). Social determinants of health such as poverty, unequal access to health care, lack of basic sanitation and improved water supply are thus, underlying factors of health inequities. Poor health outcomes are often made worse by the interaction between individuals and their social and physical environment (Marmot and Bell 2012). All infections related to the quality of water supplies are classified broadly as water borne; water washed; water based; and diseases with a water-related insect vector. According to Bradley's classification (Dar and Khan 2011); the water-borne class is fundamentally concerned with consumption of pathogens due to human or animal faecal contamination of water. Diseases like trachoma and scabies, whose incidence prevalence or

severity can be reduced by using clean water to improve personal and domestic hygiene are called water-washed. The water-based disease class is concerned with diseases where the vector lives in or adjacent to a water habitat such as schistosomiasis. Agents that breed in water like mosquitoes transmit a class of disease known as water-related insect diseases.

Helminth infections are among the most common infections worldwide affecting the poorest and most deprived communities with poor access to WaSH services. They are transmitted by eggs present in human faeces, which in turn contaminate soil in areas where sanitation is poor (Azoh 2014). Over 260 million preschool-age children, 654 million school-age children,108 million adolescent girls and 138.8 million pregnant and lactating women live in areas where these parasites are intensively transmitted and are in need of treatment and preventive interventions (Lozano et al. 2012). The burden of helminths infections is higher in the sub-Saharan region where the burden of HIV has reached epic proportions (Sartorius et al. 2020; Azoh 2014; Lozano et al. 2012; WHO 2011).

Since water supply and sanitation are critical for health, an expanded WaSH response in fighting HIV among pregnant and breastfeeding women is important to prevent multiple opportunistic infections that can accelerate rapid disease progression, and mother to child transmission of the virus (Makaudze 2019). Potable water supply and basic sanitation are a key resource for child survival, prosperity and the access to this resource under- scores the importance of Sustainable Development Goal (SDG) 6 in improving water quality and meeting many of the other SDG targets including Good health and well-being (SDG 3), Economic growth (SDG 8), and reduced inequalities (SDG 10). Yet, there is no implementable roadmap to harness benefits achievable by an integration of safe sanitation into HIV treatment, care and support services. Therefore, this research advances yet another platform as WaSH needs for HEI have largely been disregarded.

The Socio-Ecological Model illustrated in Figure 1, has cicles that place the individual in the centre while surrounded by various systems. The microsystem closest to the individual has the strongest influences and encompasses the interactions and relationships of the immediate surroundings. The second circle is the mesosystem that looks beyond immediate interactions and includes those the individual has direct contact with such as work, school, church and neighbourhood. The exosystem does not directly impact the individual, but exerts both negative and positive interactive forces on the individual such as community contexts and social networks. The macrosystem includes societal, religious and cultural values, and influences. Lastly, the chronosystem contains both internal and external elements of time and historical content. This also includes the influence of policy (Del Amo 2016).

The Socio-Ecological Models of health emphasize how factors at the intrapersonal, interpersonal, and community level greatly affect health outcomes (Carey et al. 2019). The models takes into consideration the individual, and their affiliations to people, organizations, and their community through individual, interpersonal, organizational, community, and public policy spheres. The ecological framework treats the interaction between factors at the different levels with equal importance to the influence of factors within a single level (Jahagirdar et al. 2021; Valdiserri, 2018; Abgrall and Del Amo, 2016). The Social Ecological Model has proven, in many differing situations, that in order to get the best results out of people at risk, it is best to approach the situation while addressing all levels of the framework (Jahagirdar et al. 2021). Many situations can be complicated on different levels, making a multi-faceted approach the best way to conquer a problem at all different angles. A socio-ecological framework for health outcomes, including HIV-related outcomes categorizes influences on health conditions based on the societal level at which they exist, including at the structural level (e.g., housing, poverty, WaSH status); community and interpersonal level (e.g., interpersonal relationships, social support); and individual level (e.g., mental health,

coping). (Valdiserri 2018). Structural variables, including food insecurity, financial and housing instability, and poor WaSH practices, poor access to healthcare services, can negatively affect HEI outcomes (Mimiaga et al. 2020). Lack of stable housing and low income levels are associated with poor adherence to biomedical interventions (Aidala et al. 2016). On the other hand, access to healthcare services is associated with greater adherence (Carey et al. 2019). The influence of interpersonal relationships, particularly social support, creates a supportive environment and reduces stigma.

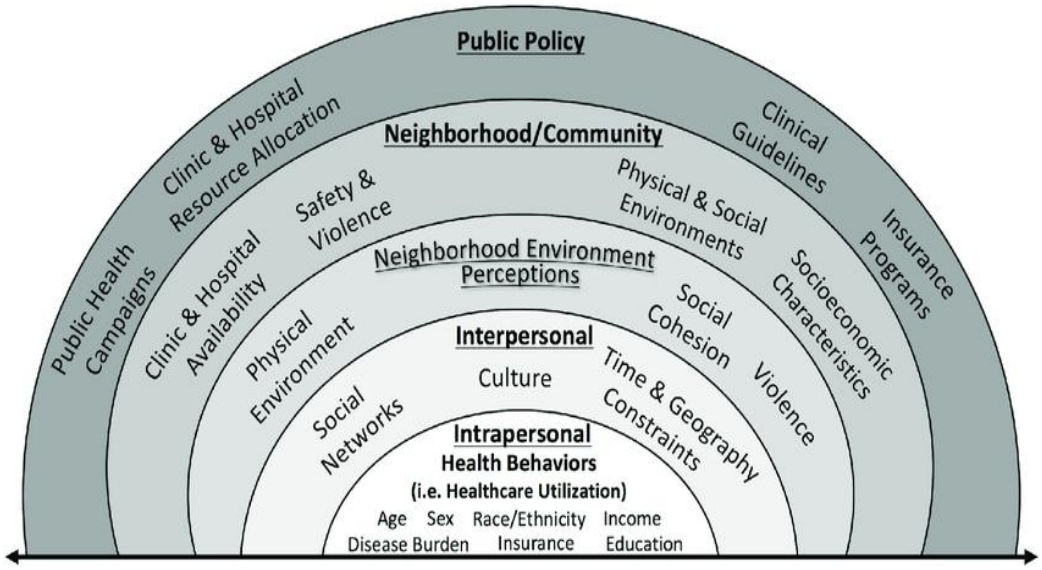

Figure 1: The Socio-ecological model of health

& how factors at the intrapersonal, interpersonal, and community level affect health outcomes

1.2. Problem Statement

Poverty, helminths co-infections, and diarrhoea linked to poor WaSH confound the HIV/AIDS epidemic and response (Campbell et al. 2016). An estimated 81,000 infants are exposed to HIV/AIDS every year in Malawi, and more than half of the infected infants die even though biomedical interventions such as Co-trimoxazole prophylaxis and short-course

anti-retrovirals (ARVS) are in place (Kim et al. 2016). Existing evidence show that Co-trimoxazole prophylaxis is recommended for HEI to prevent diarrhea as it is associated with a 41% reduction in diarrhoeal morbidity (Davis et al. 2017). However, the specific impact of enhanced WaSH practices on diarrheal prevention among this specified group, remains less explored. Further, this intervention does not modify the social environment which predisposes HEI to acquire infections. There is also lack of robust evidence to understand and quantify the magnitude of the effect of helminth infections on HIV progression. Many studies have explored the influence of handwashing, toilet location, and availability on the risk of child diarrhoea. But how these factors interact and whether their impact varies based on the child's immune status and other contextual factors is a blind spot. Insufficient quantities and quality of water compromise basic sanitation and increases HEI's vulnerability to infectious enteric pathogens such as soil-transmitted helminths, bacteria, viruses, and protozoa that infect the gut, and eventually affect the health and growth of the child (Chandna et al. 2020; Makaudze 2019). Poor WaSH and helminths have both been implicated in linear growth failure and increased systemic immune activation, which is linked to an increase in HIV-1 susceptibility respectively, but this evidence remains inconclusive (Yegorov et al. 2019) as other studies continue to produce discordant evidence. The SDH comprising a wider set of forces and systems that influence health outcomes account for up to 55% of health outcomes and clearly exceeding the contribution from the health sector (Kostelanetz et al. 2022). (Kostelanetz et al. 2022). Exposure to inadequate WaSH could indicate a higher risk of contracting diarrhoea, parasitic enteric infections, and environmental enteric dysfunction (EED), all of which can influence nutritional outcomes (World Bank Group 2019). Diarrhoea is responsible for 16% of stunting, while poor sanitation accounts for 40% (Mbuya et al. 2016). Among HIV infected children, the risk of death due to undernutrition is three times higher than non-HIV infected children (Nigussie et al. 2022).

1.3. Research Objectives

1.3.1. Main Objective

To evaluate the potential contribution of WaSH towards diarrhoea prevention, linear growth trajectory and disease progression among helminths/HIV-1 co-infections.

1.3.2. Specific Objectives

a) To estimate the effect of socio-demographic characteristics on diarrhea among HEI.

b) To establish the influence of WaSH descriptors on diarrhoea among HEI.

c) To determine the added effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis.

d) To determine the effect of improved WaSH on linear growth trajectory.

e) To evaluate the effect of helminth infections on HIV disease progression among helminth-HIV-1 co-infections.

1.3.3. Research Hypothesis

a) Demographic characteristics have no significant effect on diarrhoea among HEI in Kasungu, Malawi

b) WaSH descriptors have no significant influence on the prevalence of diarrhoea among HEI in Kasungu.

c) There is no significant added effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis.

d) Improved WaSH practices have no significant effect on linear growth.

e) Helminth infections have no significant effect on HIV disease progression among helminth-HIV-1 co-infected persons.

1.4. Significance of the study

A population characterized by healthy individuals, is critical in spurring economic growth. The Malawi 2063 (MW 2063), Enabler 5, envisions well strengthened maternal, neonatal and child health and improved health services. This vision seeks to address all forms of malnutrition and ensure that communities have access to WaSH in order to promote their health status. This study contributes to the body of knowledge of the benefits achievable by streamlining WaSH as a routine part of the HIV care programming.

Earlier researchers and partner organizations (Partners in Health, Partners in Hope, World Vision International, Plan International) in Kasungu district have focused on improving the outcomes of HEI and PLWHA through biomedical innovations (Nachega et al. 2016; Selik et al. 2014; McCollum et al. 2012. Palumbo et al. 2010). Drawing upon these findings and key lessons from published empirical evidence, we formulated our hypothesis focusing on social determinants of health (SDH) such as WaSH. Conducting this study in Kasungu was therefore important to bridge up the research gap (measuring something that people never measured before). This study offers to the Malawi research community and partner organizations in Kasungu district the much-needed evidence to inform decisions about HIV patient care by exploring the potential of complementary health approaches to foster health promotion and the maintenance of quality of life among HEI and PLWHA in Malawi. The study supports the development of effective, evidence-based HIV prevention, treatment, and care strategies in line with The Malawi Health Sector Strategic Plan III (HSSP III) which also accounts for other SDH and the need to promote sectoral partnerships, hence, it promotes joint processes for planning.

1.5. Ethical consideration

The nature, design and performance of some parts of the study that were presented as systematic reviews were submitted for registration under the International Prospective Register of Systematic Reviews (PROSPERO); an open access online data base of systematic reviews and research protocols on health-related topics. Three systematic reviews were registered in this database with the following Registration ID: PROSPERO 2021 CRD42021240512, PROSPERO 2022 CRD42022322462 and PROSPERO 2022 CRD42022364296. Permission from the Department of Water and Sanitation under the Faculty of Environmental Science was sought prior to commencement of the study. Ethical approval was gotten from the Mzuzu University Research and Ethics Committee (MZUNIREC). Approval Number MZUNIREC/DOR/22/72). The study protocol was presented to the Director of Health, Kasungu District Health Research Committee as an inception strategy to gain access to the facilities. The research goal was explained to the participants and high level of confidentiality was exercised. All persons working as research assistants were health care staff who already provide treatment, care and support to the study participants. Identification numbers were used at all times to disguise the true identity. Only participants who consented to home visits in writing met recruitment criteria. There were no penalties or loss of benefit for refusal of participation in the study or decision to withdraw from it at any point.

CHAPTER TWO: LITERATURE REVIEW

2.1. The Conceptual Framework

There is evidence that structural and environmental issues affect child health outcomes. Invariably, children with the poorest outcomes are those who are growing up within the poorest social and economic circumstances (Spencer 2018). We argue that ensuring access to biomedical services is necessary, but not sufficient. Biomedical interventions will be unable to fully address health and development issues that emerge as a result of structural challenges that the child faces. It is documented that improvements in social determinants relate to better outcomes (Braveman and Gottlieb, 2014; Komro et al. 2014; Victorian and Gauthier 2009). Similarly, where there are good social protection floors, poverty rates fall, and children thrive (Thornton et al. 2016). Comprehensive action on structural and social determinants that affect child health outcomes is required to sustain huge gains of progress in biomedical interventions which are currently in place. Synergy as defined in the Oxford languages dictionary is "the interaction or cooperation of two or more organizations, substances, or other agents to produce a combined effect greater than the sum of their separate effects". Synergy is the concept that the value and the performance of two approaches combined will be greater than the sum of the separate individual efforts. The concept recognizes that "the whole is greater than the sum of its parts". This conceptual framework postulates a need for recognition of SDH whilst harnessing the momentum of forces with health and other sectors to push for improvements in conditions in which children are born and raised as these directly affect their vulnerability to infections. For instance, HIV/AIDS is inextricably linked to social deprivation and poor WaSH practices. By definition, social deprivation is the reduction or prevention of culturally normal interaction between an individual and the rest of society. This social deprivation is included in a broad network of correlated factors that contribute to social

exclusion; these factors include mental illness, poverty, poor education, and low socioeconomic status (Bossert et al. 2007). The worst outcomes of these three manifests as diarrhoea, helminths infections and reduced gut enteropathy (nutritional malabsorption). At this level, planning interventions should aim at addressing issues regarding adoption and ownership of low-cost latrines, safe water and hygiene support, nutrition supplement support as well as social protection schemes to enhance socioeconomic livelihoods of PLWHA. Upon the successful implementation of the interventions, the following achievables are possible: reduction in the frequency and severity of diarrhoea, improved nutritional status, control of helminths and HIV co-infections and a decrease in HIV load amongst infected women of childbearing age (WCBA).

2.1.1. The relationship between the achievable and the final Outcome

The four achievables namely: reduced diarrhoea rates, improved nutritional status, controlled helminths and HIV -1 co-infections and decreased plasma viral load will lead to better immune control before this can result to Reduced MTCT. This relationship between the four acheivables and the final outcome is explained in detail below.

2.1.2. Diarrhoea and immune control

Persistent maternal diarrhoea can indeed have implications for mother-to-child transmission (MTCT) of HIV. Increased Viral Load: Persistent diarrhoea in an HIV-positive pregnant woman can lead to an increased viral load (Spencer 2018). When the viral load is high, the risk of transmitting the virus to the child during pregnancy, labor, delivery, or breastfeeding also increases (Bello et al. 2012). Diarrhoea can affect the mother's overall health, including her immune system. If the mother is experiencing persistent diarrhoea, it may compromise her ability to maintain a healthy immune system. During breastfeeding, the virus can be present in breast milk, and if the mother's immune system is weakened, the risk of

transmitting HIV to the child through breast milk becomes higher. Adequate ART is crucial for preventing MTCT of HIV. If the mother is unable to access or adhere to treatment due to health system challenges or her inability to secure adequate resources for travel, the risk of transmission increases (Chandna et al. 2020). Diarrhoea can also affect infection control practices during childbirth. If the mother has diarrhoea during labour and delivery, there may be increased exposure to bodily fluids, including blood and vaginal secretions (Kim et al. 2016). Proper infection control measures are essential to prevent transmission during childbirth. In summary, persistent maternal diarrhoea can indirectly contribute to MTCT of HIV by affecting the mother's health, viral load, and adherence to treatment. Timely identification, management, and support for pregnant women living with HIV are critical to reducing the risk of transmission to their children. This conceptual framework depicted in Figure 1 postulates a need for recognition of SDH to effectively push for improvements in conditions in which HEI live.

2.1.3. The role of nutrition on optimal immune response

Food, nutrition and health are highly interrelated, and consumption of specific nutrients have a profound impact on human health. Nutrition plays an essential role in the regulation of optimal immunological response, by providing adequate nutrients in sufficient concentrations to immune cells. According to Lean (2019), both micronutrients (minerals, and vitamins) and macronutrients (amino acids, cholesterol and fatty acids) have specific roles in immune activities such as the effective modulation of the immune function (vitamin A), the fight against infections (vitamin C), the suppression of cancer cell proliferation (vitamin D), and the regulation of the immune function (cholesterol). The amount and type of nutrients consumed are tightly linked to the metabolic stage and the immune health and thus, inappropriate nutrient consumption is associated with development of major human diseases due to an immune system not properly functioning (Gentile and Weir, 2018). The

inflammatory mechanisms that compose the innate immunity are strongly influenced by nutrition, and this interaction, when perturbed, can profoundly affect disease development. The immune system is able to destroy antigens through both innate and adaptive immune cells and finally through antibodies that are specific for each pathogen (Tapsell et al. 2016). Rich-nutrient diet is rigorously required in order to maintain an adequate health status. This is in addition to the fact that nutrients are the main factors for survival, including cell proliferation, specialization, development of tissue and organs growth, energy supply, and the immune defence function (Ross et al. 2020). When the dietary nutrients are insufficient or inefficient, the supply of these elements to the immune system cells is significantly spared and immunity is compromised.

2.1.4. Helminths and HIV-1 co-infections and the immune control

Helminths infections result from poor access to improved WaSH (Engels and Zhou 2020, Bangert et al. 2017; Bhutta, et al. 2014). Helminths disproportionately affect the poorest populations, living in remote rural areas and urban slums particularly those who have a low profile and status in the public health domain (WHO 2011). PLWHA and HEI are the most vulnerable to these conditions, which kill, impair, or permanently disable millions of people every year, often resulting in life-long physical pain and social stigma. Efficient treatment of helminths during pregnancy may reduce the risk of MTCT of HIV, by a mechanism in which parasite antigens activates lymphocytes in the utero (Li et al. 2015). Helminths can accelerate HIV-1 infection due to their profound effect on the host CD4+ cell levels and HIV plasma V/L (Downs 2017). Emmerging body of evidence suggest that this epidemiological overlap results in immune activation, impaired Th1 responses to HIV, higher viral loads, lower CD4+ counts, increased risks of antiretroviral immunologic failure, and higher likelihood of MTCT (Li et al. 2015; Ipp et al. 2014).

2.1.5. Plasma V/L and the immune control

Immunodeficiency in HIV-1 infection is accompanied by a paradoxical immune activation that results in increased cell turnover, immune system exhaustion, and AIDS (Fan et al. 2021). Immune activation is a hallmark of disease progression in HIV-1 infection. HIV-1–infected individuals are less able to spontaneously control viral replication to levels below the limit of detection of standard clinical assays (50–400 RNA copies/mL) due to the deficiency in immune system function (Jacobs et al., 2017). When HIV plasma VL escalates, it has significant implications for the immune system as it invades the immune cells, particularly CD4+ T lymphocyte cells and monocytes. As the plasma V/L increases, there is a decline in CD4+ T cell numbers below a critical level. This loss of cell-mediated immunity makes the body progressively more susceptible to multiple O.I.s due to compromised immune control (Fan et al. 2021; Jacobs et al. 2017). A high plasma V/L in a pregnant woman living with HIV impacts the risk of MTCT through pregnancy, labour, delivery, or lactation (Muenchhoff et al. 2014). A higher maternal plasma V/L during late pregnancy and/or lactation correlates with an increased risk of transmission.

All the four achievables (reduced diarrhoea rates, improved nutritional status, the control of helminths and HIV-1 co-infections and decrease in plasma V/L) are all directly linked to the prevention of MTCT of HIV as shown in Figure 1.

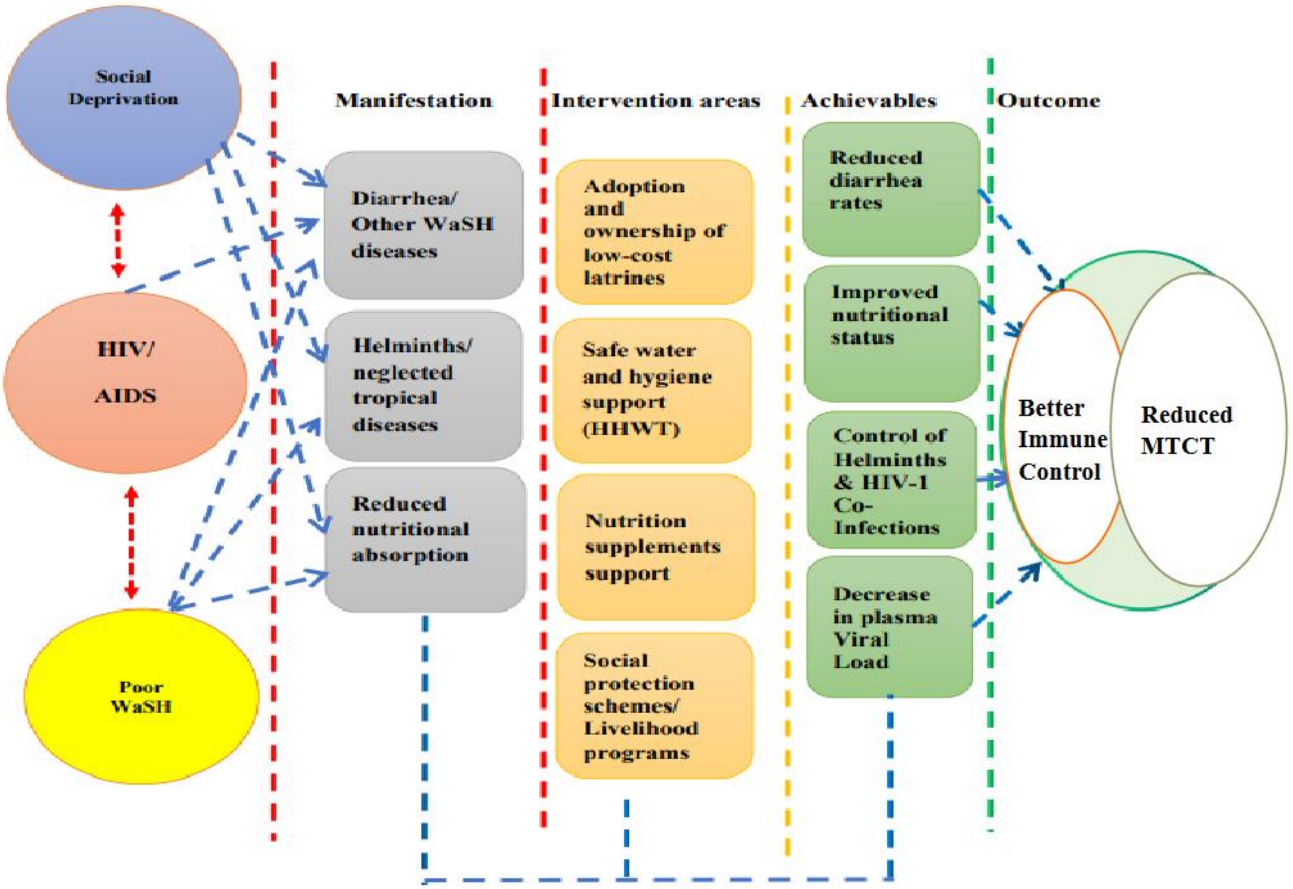

Figure 2: The Conceptual Framework

2.2. Legislation of WaSH Services in Malawi

The Malawi WaSH 'programme aims to achieve universal and equitable access to safe and affordable drinking water and adequate sanitation and hygiene for all. This includes ending open defecation and paying attention to the needs of women and other vulnerable groups. The Open Defecation Free (ODF) Malawi Strategy 2015 offers tremendous potential not only to eradicate open defecation, but also to prevent occurrence and prevalence of waterborne diseases. If effectively implemented, the strategy could drastically reduce government medical expenditure on curative treatments. For instance: The United States President's Emergency Plan For AIDS Relief (PEPFAR) is a United States government initiative that facilitates direct support and the delivery of HIV prevention, care and treatment services to help those suffering from the disease. Irrespective of the funding of HIV programs under the PEPFAR, there is persistent diarrhoea experienced by HEI and PLWHA linked to poor WaSH. This translates to loss of funds that threatens the intended goal (Garriga and Foguet, 2013). One of the key PEPFAR objectives is to reduce morbidity and mortality among PLWHA. While it is necessary to identify interventions targeted at the primary causes of HIV related illnesses, using co-trimoxazole as prevention; without having to contain he underlying cause is as good as trying to fill up a leaky bucket. For every $1 invested in water and sanitation WHO estimates a $4 economic return and a 1.5% gain of global gross domestic product (GDP) through reduced health costs, workplace productivity and fewer premature deaths. This results in $18.5 billion in economic benefits each year from prevented diarrhoea (WHO, 2014).

The ODF Malawi 2015 Strategy is in line with one of the provisions within National Sanitation Policy 2008 which states that "Open defecation shall not be tolerated in Malawi". This is in addition to creating public awareness on improved sanitation, creating effective linkages between all relevant sanitation stakeholders and promotion of integrated and holistic

planning, development and design of sanitation and hygiene promotions initiatives and programmes. The strategy basically aims at harmonizing sanitation and hygiene initiatives and interventions towards meeting the goals of the Malawi Growth and Development Strategy (MGDS) II. The Malawi Growth and Development Strategy (MGDS), which was developed in 2006, among other things seeks to increase access to clean water and sanitation, improve the nutritional status of children and ensure food security. The National Water Policy developed in 2005, endeavors to ensure availability of efficient and effective water and sanitation services that satisfy the basic requirements of every Malawian and for the enhancement of the country's natural ecosystems. The National Environmental Policy, adopted in 2004, outlines the need for pollution control and the proper disposal of wastewater, solid waste and the protection of water bodies, with the general principle of 'polluter pays'. The Public Health Act, the Pharmacy, Medicines and Poisons Act as well as a number of guidelines covering the safe disposal of hazardous and non-hazardous waste at health facilities; the Local Government Act and Decentralization Policy, which promote accountability and good governance at the local level in order to help government reduce poverty; and mobilizing the masses for socio-economic development.

According to the SDG progress report of 2023, approximately 2.2 billion people in 2022 lacked access to WaSH which is viewed as a human right violation. Interestingly, the report highlights the need for accelerating integration strategies and cross-sectoral coordination and partnership. Nevertheless, the growing challenges faced by HEI and PLWHA are often linked to water scarcity, water pollution, and hygiene challenges which is a considerable threat to attainment of SDG 6 (Sanitation for all). Shrestha et al. (2023), in their study in Nepal conceptualize widening inequalities between poor and rich residents, and between genders due to lack of capacity to provide and maintain WaSH services, financial issues, and unfavourable policies. The study proposes robust and joint WaSH sector planning in Nepal to

safeguard the rights of the most vulnerable society groups. The policy instruments in Malawi, (MGDS II, the National Water Policy, the National Environmental Policy, the Public Health Act, the Local Government Act and Decentralization Policy), all seek to promote socio-economic development through the provision of improved and sustainable WaSH services for the poor and other vulnerable population groups. However, there is no common implementation plan of action to integrate and leverage resources among partner organizations, as this could enhance the most efficient use of funds, personnel and other resources within the WaSH and HIV sector.

2.3. Alignment of the Local HIV Policies to International Guidelines

Virologic assays such as HIV RNA or HIV DNA nucleic acid tests (NATS) that directly detect HIV are used to diagnose infants and children aged below 12 months with perinatal or postnatal HIV exposure (Persaud et al. 2013). HIV can be definitively diagnosed by virologic testing in most non-breastfed infants with perinatal HIV exposure by age 1 to 2 months and in virtually all infants with HIV by age 4 to 6 months (Wessman et al. 2012). Antibody tests, including the antigen-antibody combination immunoassays (sometimes referred to as fourth- and fifth-generation tests), do not establish the presence of HIV in infants because of transplacental transfer of maternal HIV antibodies. Therefore, a virologic test must be used (Selik et al. 2014; Palumbo et al. 2010). Antigen/antibody combination immunoassays that detect HIV-1/2 antibodies as well as HIV-1 p24 antigen are not recommended for diagnosis of HIV infection in infants. In the first months of life, the antigen component of antigen/antibody tests is less sensitive than an HIV NAT, and antibody tests should not be used for HIV diagnosis in infants and children aged below 12 months of age (Kwena et al. 2021; Gray et al. 2018).

The Malawi's National HIV program has undergone several important policy changes since its inception in 2004. In 2011, Malawi modified the relevant World Health Organization (WHO) guidelines to design a unique national strategy for PMTCT called Option B+ that enabled all pregnant and lactating women found infected with HIV to start lifelong cART, regardless of their CD4+ T lymphocyte counts or WHO clinical stage. The strategy was designed to reduce maternal mortality and to improve child health outcomes through early initiation of cART. Another prominent policy change is the operationalization of the National *Paediatric HIV Testing and Counselling guidelines to* complement the Malawi *HIV Counselling and Testing Guidelines* (Ministry of Health 2004). They inform a procedure and set standards for HIV testing and counselling of infants and children who present for treatment and care in health care facilities. These guidelines contribute to the achievement of targets set in the Malawi HIV/AIDS Action framework (2005-2009) and the minimum *elimination of mother to child transmission* (EMTCT) impact targets.

Protocols for HIV testing and counselling in children are separated into two distinct age groups: children at 18 months of age and younger, and those older than 18 months of age. This distinction is necessary because testing children 18 months of age and younger poses a technical challenge that is not present in those older than 18 months of age. Due to the persistence of maternal antibodies in the bloodstream of infants born to HIV-infected mothers, virologic tests must be done to confirm infection in infants younger than 12 months of age. Presented below in Table 1 is an algorithm for the symptomatic/clinical diagnosis of HIV infection in children less than 18 months.

Table 1: The Malawi Schedule of HIV testing for children (Algorithm)
(Adapted from The Malawi HIV treatment Guidelines, 2019)

Age (months)	Test	Schedule	Result	Interpretation	Action
Under 12	DNA-PCR (if available)	First opportunity from age 6 weeks	Negative	Not infected, but at risk of infection if breastfeeding	Continue HCC. Do rapid test at age 12 months.
			Positive	HIV infected	Start ART. Confirmatory DNA-PCR at ART initiation.
	Rapid antibody	Immediately if signs of PSHD identified ***OR*** If mother's HIV status cannot be ascertained	Negative	Not infected, but at risk of infection if breastfeeding	Treat condition. Continue HCC. Repeat rapid test at age 12 and 24 months.
			Positive	Possibly HIV infected if no PSHD symptoms	Enrol in HCC. Do DNA-PCR at first opportunity.
				Likely AIDS if symptoms for PSHD	Start ART. Confirmatory DNA-PCR at ART initiation.
12 to under 24	Rapid antibody	From age 12 months ***OR*** If mother's HIV status cannot be ascertained	Negative	Not infected, but at risk of infection if breastfeeding	Continue HCC, repeat rapid test at age 24 m.
			Positive	HIV Infected	Start ART. Confirmatory DNA-PCR at ART initiation.
24 and above	Rapid antibody	From age 24 months but ensure that BF stopped at least 6wks ago	Negative	Not infected	Discharge child from HCC.
			Positive	HIV Infected	Start ART. Confirmatory (parallel) rapid test at ART initiation.

2.4. Co-trimoxazole Prophylaxis- Rationale and Recommendations for Usage

To reduce the risk of HIV-associated opportunistic infections, WHO recommends that infants exposed to HIV through breastfeeding receive co-trimoxazole prophylaxis from 6 weeks of age until an age-appropriate HIV test can be used to ascertain the child's infection status after cessation of breastfeeding. Timely linkage and adherence to age-appropriate level of care reduces morbidity and mortality. Figure 2 below illustrates the standard schedule of HIV-exposed child follow up (infant NVP prophylaxis, Co-trimoxazole prophylaxis, infant feeding and HIV testing). The schedule focuses on biomedical interventions which are lined up from the birth of the child until the child reaches the age of two years. Co-trimoxazole prophylaxis is given across the entire twenty-four months child follow-up period. Other interventions which are also biomedical in nature are the administering once-off nevirapine (NVP) within

the first six weeks of life, three DNA-PCR, first and second Rapid antibody tests at intermediate time-points of six weeks, twelve and twenty-four months respectively (See Figure 2). The rationale of the two forms of prophylaxis is centred around prevention of child diarrhea and promoting better health. This model of treatment, care and support totally overlooks the very determinants of the illness particularly in the context of poor settings, where the burden of diarrhea and other WaSH related diseases is particularly high.

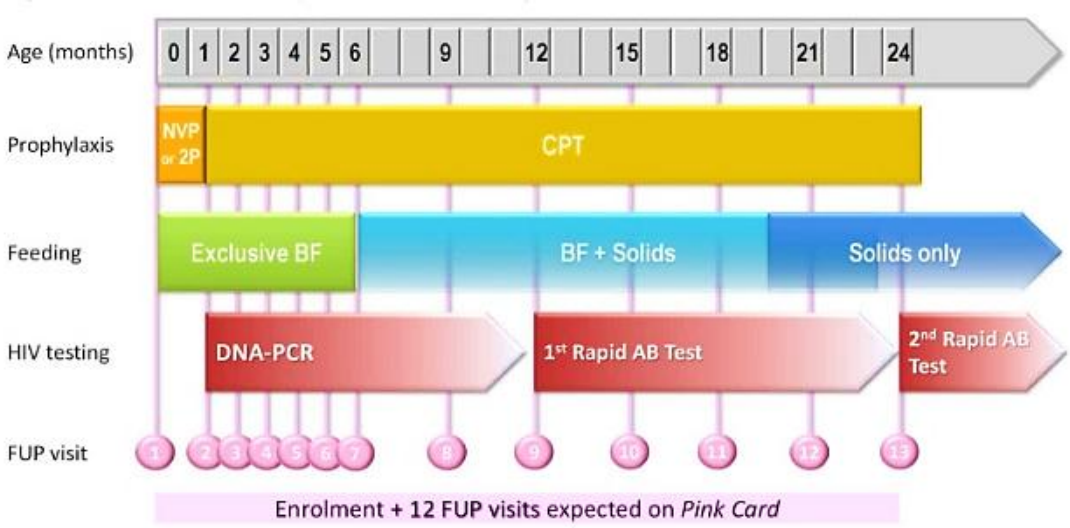

Figure 3: Standard follow-up schedule for HIV-exposed infants (Adapted from The Malawi Clinical HIV Guidelines-2022 Edition)

2.5. Theoretical Framework

The SDH are the non-medical factors that comprise a wider set of forces and systems that influence health outcomes (Marmot and Wilkinson 2008). They include but not limited to the geo-political systems, economic systems and policies, social norms and policies and the development agenda. The SDH have an important influence on health inequities - the unfair and avoidable differences in health status seen within the population. Recent studies (Witt et al. 2022; Redeker et al. 2021; Marmot et al. 2018) suggest that SDH account for between 30-55% of health outcomes and exceeds the contribution from the health sector. Other studies (Spencer, 2018; Granberg et al. 2015; De Coninck et al. 2014) link low-income status to increased vulnerability to HIV acquisition owing to lack of accessibility to health services. Above all, lack of formal or informal employment increases the risk of people not being able to pay for medical care when required or access it in terms of distance and other barriers (Fonner et al. 2012). Also, people living in unfavourable socioeconomic conditions might not have the financial capacity to purchase or access the biomedically prescribed preventive health services that can limit the spread of the infection from mother to child. SDH are irrefutably a mechanism for disease transmission and acquisition that is of equal importance. The only difference is whether we approach the issue from the perspective of a biomedical professional rather than that of a public health and social perspective. At a minimum, appreciation of some of the social factors that influence health can help in developing more effective integrated treatment plans.

The role of SDH in the trajectory of the HIV epidemic has received increasing recognition in the recent years through epidemiologic studies designed to assess the role of SDH through observational, intervention and randomized trial designs (Jahagirdar et al. 2021; Valdiserri, 2018; Abgrall and Del Amo, 2016). Through various dynamic compartmental models, social factors such as stigma, poverty, poor WaSH practices and poor access to health care services

have been singled out to represent complex constructs that impact on HIV disease prevention and treatment outcomes in the sub-Saharan Africa region (Jahagirdar et al. 2021). The broad social and economic circumstances that together determine the quality of the health of the population are illustrated in the theoretical framework of this study laid out in Figure 3 below.

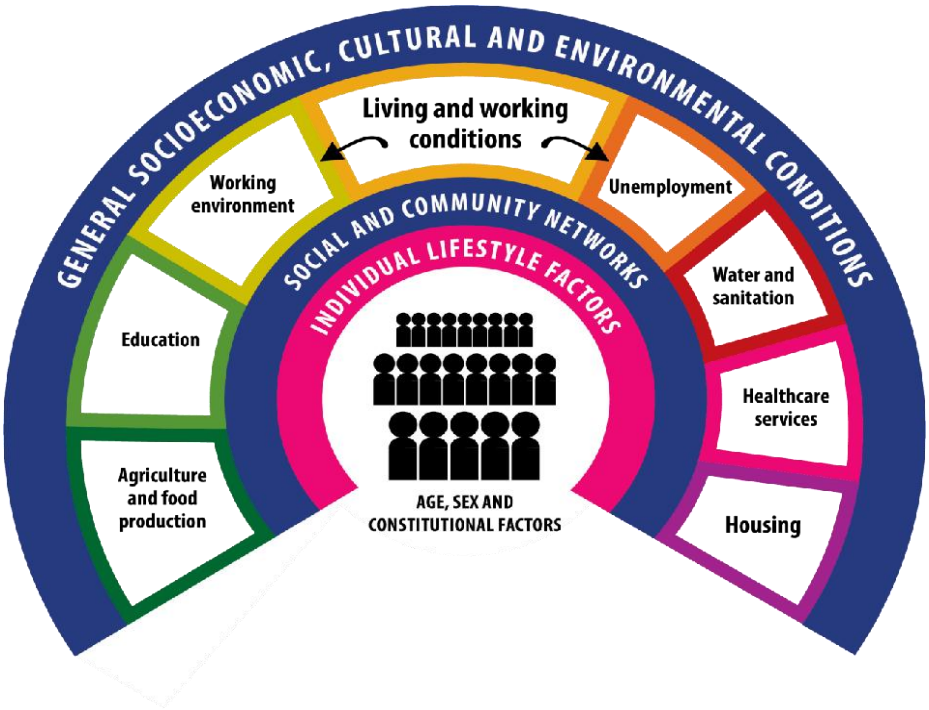

Figure 4: Theoretical Framework (Dahlgren and Whitehead 1991)

This theoretical framework (social ecological theory to health) attempts to map the relationship between the individual, their environment and disease. This study explored the determinants of diarrhoea and other WaSH related diseases from an eco-social and behavioural perspective using the Dahlgren and Whitehead (1991) model of determinants of health. The model explains the different layers of influence on the health of an individual. The social model of health considers a broader range of factors that influence health and well-being, for example, environmental, economic, social and cultural aspects.

Individuals are at the centre with a set of fixed genes. Surrounding them are influences on health that can be modified. The first layer is personal behaviour and ways of living that can promote or damage health. –eg choice to smoke or not-Individuals are affected by friendship patterns and the norms of their community. The model describes a social ecological theory to health and aims to map the relationship between the individual, their environment and the disease. Individual characteristics such as age and sex are at the centre of the model. The second layer includes the personal behaviour and ways of living that can promote or damage the health. This layer is about social and community influences, which provide mutual support for members of the community in unfavourable conditions. But they can also provide no support or have a negative effect. The third layer includes structural factors: housing, working conditions, access to services and provision of essential facilities. The outermost layer talks about the general socioeconomic, cultural and environmental conditions.

Empirical evidence from high quality studies that have applied the Dahlgren and Whitehead (1991) social ecological theory to explain the cause of child illness, have demonstrated that diarrhoea has multiple pathways of transmission (Fontoura et al. 2018) but the most common is poor WaSH practices, sub-optimal waste management practices, poorly built houses with lack of basic infrastructure, social inequality, low socioeconomic status, overpopulation, low level of knowledge of mothers and difficult access to public health services (Mirhoseini et al. 2018; Curtis et al. 2013; Oliveira et al. 2009). To be effective and sustainable, disease prevention strategies need therefore, to be sufficiently powerful to overcome the prevailing social, structural and environmental factors whose lack of conceptualization and operationalization have potential to impede progress in building effective interventions.

2.6. The influence of WaSH descriptors on diarrhoea

Globally, diarrhea is the second leading cause of death in children less than 5 years of age (Pavlinac 2015). Although access to safe sanitation is a basic human need (Luby 2014), a significant proportion of HEIs have no access to it (Makaudze 2019). The lack of high quality sanitation increases HEI‘s vulnerability to diarrhea, gut enteropathy and S-THs (Chandna et al. 2022). HEIs are four times more at risk of diarrhea compared to children who are not exposed; six times more likely to have diarrhea if they stayed much closer to a caregiver with diarrhea in the last seven days Peletz et al. 2011) and eleven times more likely to die from diarrhea if they have confirmed HIV infection than uninfected children (Eijk et al. 2010). This increased vulnerability is a serious public health issue that warrants attention.

Water interventions are meant to improve the quantity (e.g. water trucking), quality (household latrine utilization) separate feces from the environment and hygiene interventions prevent transmission by cleaning oneself or the home environment (e.g. handwashing with soap) (Afework et al. 2022). Regular and appropriate latrine utilization, safe water supply, handwashing, building healthy habits and skills have proved to be the best way to stop disease-causing microbes from spreading (Anthonj et al. 2021). The common potential pathways for transmission in the fecal-oral route are summarized as five Fs: fingers, flies, fields, fluids, and food as shown in figure 4 below.

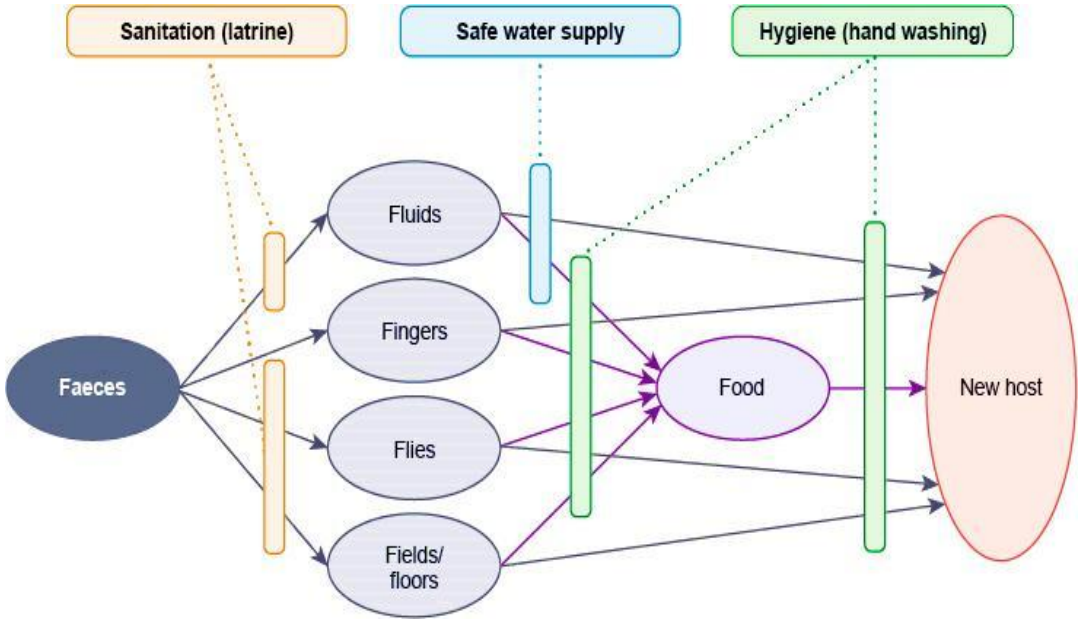

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Figure 5: The F-Diagram

(This figure appears at www.ajtmh.org.)

The F-Diagram is one of the many tools which seeks to vividly describe in detail the fecal oral transmission route. It is a cycle characterized by F's as follows:

a. **Fluids**-the drinking of contaminated water

b. **Fields**-the contamination of soil, crops, fruits etc by human excreta

c. **Fingers**-faecal contamination of fingers/hands

d. **Food**-eating food contaminated with fecal matter

e. **Flies**-which spread diseases from feces to water and food.

All of the transmission routes shown in the F-diagram (Figure 4) can be blocked by changes in domestic hygiene practice. Improved infrastructure, such as water and excreta disposal facilities, can also contribute to preventing transmission. However, public infrastructure can only be fully effective if employed in conjunction with safe hygiene practices in the home (Anthonj et al. 2021).

The diagram allows a distinction to be made between primary and secondary measures to prevent the spread of diarrheal pathogens in the environment. Primary barriers are the practices that stop this happening. These include the disposal of stools in such a way that they are isolated from all future human contact (by the use of latrines). Secondary barriers are hygiene practices that stop fecal pathogens that have got into the environment in stools or on hands, from multiplying and reaching new hosts. Secondary barriers include washing hands before preparing food, cooking, storing and re-heating food in such a way as to avoid pathogen survival and multiplication. They also include protecting water supplies from fecal contaminants and water treatments such as boiling or chlorination. Other secondary barriers include keeping play spaces free of fecal material and preventing children from swallowing soil.

Interventions to encourage the safe disposal of stool and adequate handwashing after stool contact are more helpful than those that concentrate on the secondary barriers (Koyra et al. 2017). Open defaecation around living areas is associated with an increased incidence of diarrhoea (Ogbo et al. 2018; Ahmed et al. 2020). Other studies (Ellis et al. 2020; Sakisaka et al. 2015) suggest that latrine ownership on its own may not be sufficient to prevent disease, unless if tied to safe stool disposal behaviour. Koyra et al. (2017) found a close association between latrine ownership and the prevalence of diarrhoea among households with access to a latrine. The study demonstrated that households who own latrines were less likely to contract diarrhoea than their counterparts living in households without a latrine.

The influence of latrine proximity and diarrhoea has been reported in other studies. Odagiri et al. (2016) found that the correlation between population and latrine count increased with distance, suggesting that an increase in population increase also captures the effect of a latrine increase. Similar observations have been reported by Getachew et al. 2018; Natnael et al. 2021.

Based on the JMP water ladder, drinking water services are classified as safely managed, basic, limited, unimproved, and surface water (no service). The JMP service ladders are used to benchmark and compare service levels across countries. These have been updated and expanded to facilitate enhanced global monitoring of drinking water, sanitation and hygiene. Table 2 below shows the JMP ladder for household drinking water services.

Table 2: JMP ladder for household drinking water services (Available from JMP WASHdata website)

Service Level	Definition
Safely managed	Drinking water from an improved water source which is located on premises, available when needed and free of fecal or microbial contamination
Basic	Drinking water from an improved water source provided collection time is not more than 30 minutes for a round trip including queuing
Limited	Drinking water from an improved source where collection time exceeds over 30 minutes for a round trip to collect water, including queuing
Unimproved	Drinking water from unprotected dug well or unimproved spring
No service	Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

The existing JMP core questions for household surveys have been widely used in national household surveys and censuses worldwide and have contributed to improvements in the quality and comparability of data collected over the past decade.

In a study conducted in Ethiopia by Wagari et al. (2022), the Poisson regression on the WaSH service ladder and its contribution to diarrhoea among children aged below five years, showed that WaSH service ladders were significantly associated with childhood diarrhoea. Households utilizing basic services (APR= 0.27; 95% CI: 0.12-0.57) and limited services (APR=0.45; 95% CI: 0.23-0.89) had significantly reduced the prevalence of diarrhoea

compared to those using surface water. Similarly, households in the basic sanitation service ladder had 83% less diarrhoea (APR= 0.17; 95% CI: 0.05-0.56) compared to those practicing open defecation. In the same study, handwashing after using the latrine by child caregivers was protective against child diarrhoea (65% lower diarrhoea prevalence) than those who do not practice handwashing. Soboksa et al., (2021)found that improved latrine utilization of the study participants in Ethiopia was 17.3%, which is lower than that of studies conducted in Uganda (21.3%), Indonesia (69%), Vietnam (47.1%) and SDG targets to achieve and sustain 100% access to improved sanitation in rural and urban areas by 2030.This study which was conducted in Ethiopia also found that the improved water supply utilization of the study participants was 59.3%, even though there was variation between regional states. This finding was lower than study's findings from Indonesia (62%), India (83%), and the Democratic People's Republic of Korea (93.7%).15,30,31 However, this finding is higher than that in another study from Indonesia (31.6%).32 The possible explanations for this finding being different might be related to sample size, study setting, socioeconomic and differences in the year of study. Furthermore, 24.8% of the study participants practiced safe child feces disposal. It is relatively similar to findings reported in India (23.7%)33 and Bangladesh (20%).34 However, the findings were lower than those reported in Ethiopia (33.68%),35 Indonesia (47%),15 Uganda (75%), 36 and Kenya (70%).37 The difference could be related to the study participants' socio-economic differences or implementation of the sanitation approach of child feces disposal practices in the community.

Although access to an improved water supply is an important cornerstone in reducing prevalence of diarrhoea, studies have identified that collecting water from improved sources alone does not have a guarantee to reduce the risk of diarrhoea since the contamination of drinking water can occur in the distribution system or at home after water treatment has already occurred (Kyereme and Adjei 2016). Thiam et al. (2017), in their study of the

prevalence of diarrhoea and risk factors among children under five years old in Mbour, Senegal found that children living within wealthy families were less likely to have diarrhoea because the wealthier families have better access to improved WaSH services within the confines of their homes and frequently use better health services. The findings of this study confirmed the previous findings (Kyereme and Adjei, 2016; Osumanu et al. 2007) that, as the households indexed as poor wealth index were more likely to develop childhood diarrhoea compared to those indexed as well-off.

2.7. Added effect of co-trimoxazole prophylaxis and safe water on diarrheoa

Excessive child diarrhea due to unsafe water in sub-Saharan Africa is a tragic but familiar story. Although access to safe water is a basic human need that ensures personal hygiene and restores human dignity (Luby 2014), a significant proportion of HEI have no access to it (Makaudze 2019). Many life-threatening opportunistic infections amongst HEI are caused by exposure to unsafe water, inadequate sanitation and poor hygiene (Daniels et al. 2019). The lack of safe water increases HEI's vulnerability to infectious enteric pathogens and gut enteropathy, which hinders the proper absorption of medicines and makes them less effective (Chandna et al. 2020). Safe water significantly reduces the odds of child diarrhoea by up to 45% (WHO 2014). Many studies (Makaudze 2019; Daniels et al. 2019; Kamuhabwa and Manyanga 2015), point to the fact that basic sanitation is key for child survival. Whilst there is evidence that high quality sanitation affect child health outcomes, there is no implementable roadmap to harness benefits achievable by an integration of safe water into HIV treatment, care and support services.

The population of HIV-exposed infants is expanding, and reached nearly 15 million in 2017 (Chandna et al. 2020). Co-trimoxazole is one of the main biomedical interventions recommended by World Health Organization (WHO) in the management of HEI. It contains two antibiotics: sulfamethoxazole and trimethoprim. Trimethoprim and sulfamethoxazole have enhanced effect when used concomitantly. This is because they inhibit sequential stages in the folate synthesis pathway of the microorganisms. It is commonly abbreviated in the following ways: SXT, TMP-SMX, TMP-SMZ or TMP-Sulfa.

To reduce the risk of HIV-associated opportunistic infections, WHO recommends that infants exposed to HIV through breastfeeding receive co-trimoxazole prophylaxis from 6 weeks of age until an age-appropriate HIV test can be used to ascertain the child's infection status after

cessation of breastfeeding. Co-trimoxazole is associated with a 36% reduction in respiratory morbidity and a 41% reduction in diarrhoeal morbidity (Davis et al. 2017). This systematic review was carried out to gather and synthesize evidence on the effectiveness of integrating safe water and co-trimoxazole preventive therapy in reducing morbidity and mortality among HEI. The question that this systematic review tries to resolve is: What is the combined effect of improved water supply interventions and co-trimoxazole preventive therapy on frequency and severity of diarrhea among HIV exposed infants and PLWHA? Is the value and performance of two approaches combined much greater than the sum of the separate individual efforts? The target main outcome of the review was diarrhoea among HEI and PLWHA.

2.8. The effect of improved WaSH on linear growth

Most countries are ill-prepared to meet the global target to reduce stunted growth among under-five children by 40% by 2025 (Goal 2: Target 2.2) as current investment efforts are insufficient to drive progress to achieve the set goal (Shekar et al. 2017). Fortunately, there is a growing body of evidence that indicates that WaSH could be critical in addressing children's nutritional deficits including stunting, which is considered a main indicator for chronic malnutrition. At the direct, biological level, soil transmitted helminths, repeated diarrheal episodes and environmental enteric dysfunction (EED) are thought to be pathway linkages between WaSH and linear growth failure. Prolonged exposure to fecal pathogens increases vulnerability to enteric infections that contribute to environmental enteric EED (Chandna et al. 2020), a postulated condition characterized by malabsorption, villas atrophy, crypt hyperplasia, T-cell infiltration and inflammation of the jejunum. EED is known to reduce oral vaccine efficacy, gut absorption and is implicated as a cause of stunting, an irreversible, and an easy-to-measure manifestation of early childhood developmental deficit (Budge et al. 2019).

WaSH may particularly contribute to undernutrition when it cannot prevent high fecal pollution of the environment (Mbuya et al. 2016). Exposure to inadequate WaSH could indicate a higher risk of contracting diarrhoea diseases, parasitic enteric infections, and environmental enteric dysfunction (EED), all of which can influence nutritional outcomes (World Bank Group 2019). The etiology of this state of intestinal inflammation without overt diarrhoea may be multi-factorial but predominantly occurs in children who are constantly exposed to poor sanitation and water contamination. This chronic infection of the small bowel could explain why sanitation may have a stronger association with gains in growth than with reductions in diarrheal incidence. Studies have shown that diarrhoea is responsible for 16% of stunting, while poor sanitation accounts for 40% (Mbuya et al. 2016). Environmental enteric dysfunction is known to reduce absorption of oral vaccine. This is probably the reason oral vaccines for the control of rotavirus have shown poor efficacy in Sub-Saharan Africa (39.3%) and Asia (48.3%), in very sharp contrast to Europe and other developed countries (85-98%). Stunting affects 165 million children globally (Black et al., 2013). In 2020, 22% of children under the age of five had stunted growth, representing a staggering loss of both human and economic potential. The vast majority of the stunted population lives in Sub-Saharan Africa and South Asia as each of them contributes 59 million and 87 million respectively to the global burden of stunting (Berhanu et al. 2018). Among HIV infected children, the risk of death due to undernutrition is three times higher than non-HIV infected children (Nigussie et al. 2022). Recent studies have shown that stunting, underweight and wasting are more prevalent among HIV exposed and infected children in the sub Saharan Africa region (Poda et al. 2017; Anyabolu et al. 2014; Sunguya et al. 2011).

Linear growth faltering may occur within the first two years of life and then, for the most part, is irreversible, necessitating early diagnosis if prevention or cure is to be successful. A stunted child has also long-term cumulative effects that include poor cognitive abilities,

increased risk of Non-Communicable diseases (NCDs) in later life and a marked decrease in the national economic output (Black et al. 2017). Height-for-age is a measure of height compared to the height of children of the same age and sex from a reference population (Reese et al. 2021). It is indicator of chronic malnutrition, which is used to identify stunted growth. A child is considered stunted if they have a height-for-age Z-score below 2 standard deviations compared with the WHO Child Growth Standards median of the same age and sex. Figure 1 below conveys schematic pathways of environmental enteric dysfunction (EED).

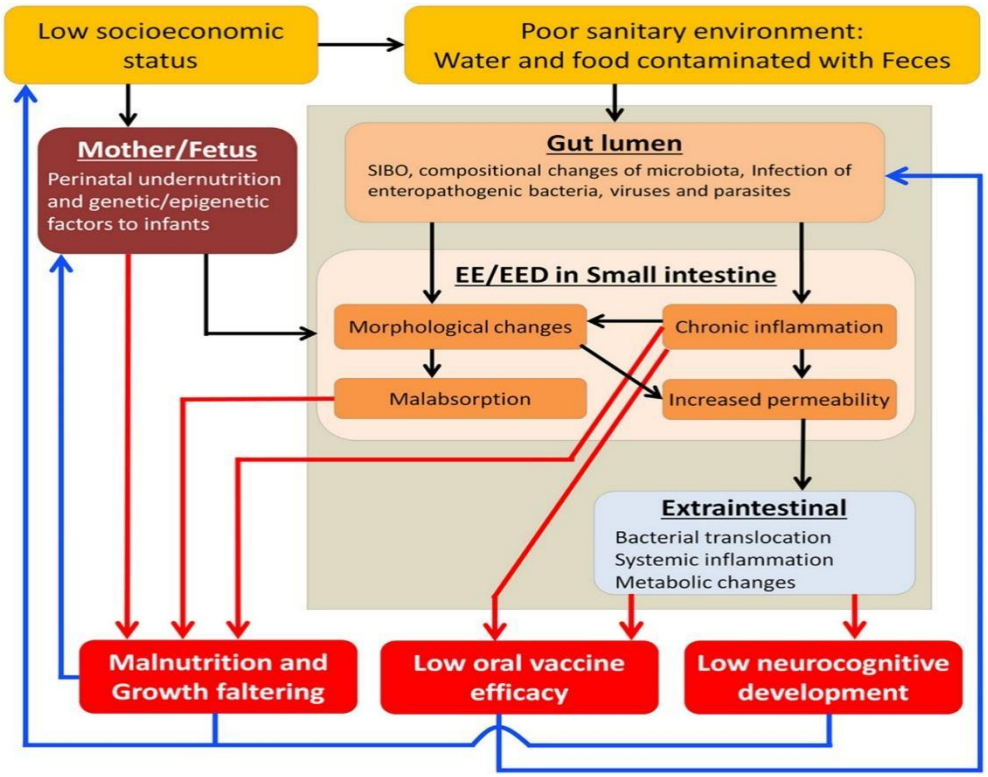

Figure 6: Pathogenesis of environmental enteric dysfunction (EED) (Adapted from Watanabe and Petri, 2016)

2.9. The effect of helminths infections on HIV disease progression among helminth-HIV-1 co-infected persons

Benefits of improved WaSH extend well beyond the risk of diarrhoea. They include a reduction in the spread of neglected tropical diseases (NTDs) such as helminths infestation, a disease condition that is associated with very poor WaSH practices (Campbell et al. 2018).

Efficient treatment of NTDs during pregnancy may reduce the risk of MTCT of HIV, by a mechanism in which parasite antigens activates lymphocytes in the utero (Li et al. 2015). Some studies (Downs 2017) suggest that NTDs accelerate HIV-1 infection in poor-resource settings due to their profound effects on the host immune system, which make those infected more susceptible to HIV-1 infection and less able to cope with it. Concurrent infections with NTDs such as helminths and HIV-1 is common among persons who have poor access to improved sanitation. The type 1/ type 2 model of immune responses to infection suggests a detrimental effect of helminths infection, since the balance in favor of type 2 cytokines at the expense of type 1 cytokines encourages HIV-1 disease progression (Ipp et al. 2014).

2.9.1. Epidemiology of Helminths infestation

The Global Burden of Disease Study 2010 reports an increase of 111,000 deaths globally attributable to neglected tropical diseases (NTDs) (including leishmaniasis, trypanosomiasis, schistosomiasis, cysticercosis, echinococcosis, malaria, dengue, ascariasis, and other forms of helminths) also collectively referred to as 'infectious diseases of poverty' (IDoPs) with Sub-Saharan Africa bearing the worst outcomes from their impact (Sartorius et al. 2020; Azoh 2014; Lozano et al. 2012; WHO 2011). While neglected, infectious tropical diseases, are much alive and primarily concentrated in poor settings of Sub-Saharan Africa, Asia, and Latin America, with geographic overlap resulting in high levels of co-infection (Engels & Zhou 2020, Bangert et al. 2017; Bhutta, et al. 2014; Alsan et al. 2012). The global pattern of helminths infestation and the geographical distribution within the Sub-Saharan region is shown in Table 3 and figure 5 respectively.

Table 3: Global Distribution of Different Helminths

Helminth Type	Regional Distribution
Ascariasis lumbricoides (roundworm)	Asia, Africa and Latin America
Trichuris trichiura (whipworm)	Asia, Africa and Latin America
Ancylostoma duodenale (Hookworm)	Asia, Africa and Latin America
Strongyloides stercoralis (threadworm)	Asia, Africa and Latin America
LF Wuchereria bancrofti; Brugia malayi	India, Southeast Asia Sub - Saharan Africa
Onchocerciasis (river blindness)	Sub - Saharan Africa
Loiasis Loa loa	Sub - Saharan Africa
Dracunculiasis (guinea worm)	Sub - Saharan Africa
Schistosomiasis Schistosoma haematobium	Sub - Saharan Africa
Schistosoma mansoni	Sub - Saharan Africa and Eastern Brazil
Schistosoma japonicum (blood flukes)	China and Southeast Asia
Clonorchis sinensis (liver fluke)	Developing regions of East Asia
Opisthorchis viverrini (liver fluke)	Developing regions of East Asia
Paragonimus spp. (lung flukes)	Developing regions of East Asia
Fasciolopsis buski (intestinal fluke)	Developing regions of East Asia
Fasciola hepatica (intestinal fluke)	Developing regions of East Asia
Cysticercosis Taenia solium (pork tapeworm)	Sub - Saharan Africa

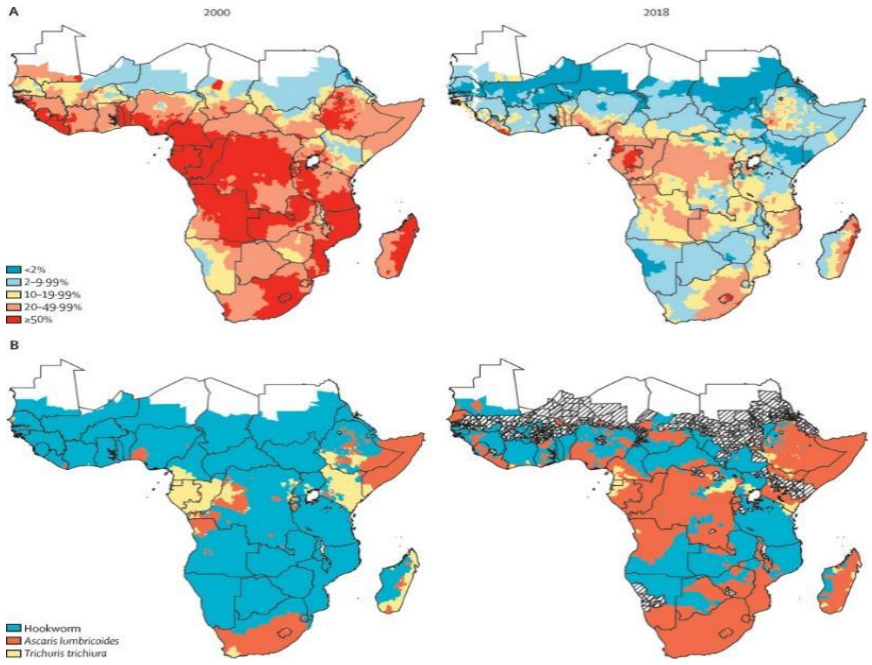

Figure 7: Illustrative distribution of helminths in Sub-Saharan Africa (Sartorius et al. 2020)

2.9.2. Intersections Between HIV-1 and Helminths

During an acute phase of infection, HIV reproduce in large amounts and destroy CD4+ cells and levels typically fall quickly at first (Richmond et al. 2021; Mpairwe et al. 2014; Elliott et al. 2014). As the immune system responds, viral load begins to fall and the CD4+ levels start to rise again but they may not return to pre-infection levels. Helminths have been implicated in increased systemic immune activation, which is linked to an increase in HIV-1 susceptibility (Bello et al. 2012; Stillwagon, 2005). Through complex molecular mechanisms, both HIV-1 and helminth infections can lead to depletions in CD4+ T-lymphocyte cells, (Blackwell et al. 2016) and treatment of helminths has been associated with delays HIV-1 progression and improvements in CD4+ counts and reductions in HIV-1 RNA (viral load) (Means et al. 2016). HIV-1 RNA (viral load) and CD4+ T lymphocyte cell (CD4+) count are surrogate markers of antiretroviral treatment responses and HIV disease

progression that have been used for decades to monitor HIV infection (WHO 2013; Mermin et al. 2011). CD4 count is the best predictor for the immune function, hence useful in the identification of advanced HIV disease (WHO 2013; Mermin et al. 2011; Woodburn et al. 2009).

The primary outcome of the study was plasma HIV-1 RNA Viral load (V/L) amongst helminth-HIV-1 co-infected persons while secondary outcomes were (1) Cluster of Differentiation (CD4+) T-lymphocyte count, (2) maternal HIV-1 transmission (MTCT) and (3) mortality and other adverse events. The current method used for staging HIV infection in settings with limited resources is the sole measurement of CD4+ T cells (CD4 count test). WHO recommends a cut-off value of 200–350 CD4+ T cells/μl for adults; patients with values below this should be initiated on antiretroviral treatment (WHO 2003). Viral load test result might be reported as "<20", "<50", "<200", "undetectable", "not detected" (ND), "target not detected" (TND), "below the limit of detection" or "zero". A normal viral load means less than 20 to 75 copies of the human immunodeficiency virus (HIV) per milliliter of blood. A normal viral load may indicate: Low risk of HIV infection. Zero risk of transmitting infection.

2.7. WaSH, HIV and Poverty Complex Linkages

Historically, low income has been a driver of public health problems. There is robust literature that substantiates the claim that income inequality widens health disparities, thus cause for health concern (Yakubu et al. 2014). Poverty means that the income level from employment is so low that basic human needs can't be met (Bossert et al. 2019). A poverty rate is the share of units in households in which total household consumption (divided by the number of household members) is below a given poverty line (Teka et al. 2019). Each household member has the same poverty status (or estimated poverty likelihood) as the other

household members. Poverty-stricken people and families are likely to go without clean water and improved WaSH services. This increases their living costs, lower their income earning potential, damage their well-being and put their life at risk (Yakubu et al. 2014). The lack of convenient and affordable access to water reduces a poor household's consumption of other commodities and services, leaves it consuming less than the optimum amount of water for good hygiene, and impacts health and labour productivity of the household members (Teka et al. 2019; Bossert et al. 2019; Nketiah et al. 2019). Wealth positively influences household ownership of improved sanitation (Mariwah et al. 2017). Beyond poverty, a mix of cultural, social, political and economic problems have a strong influence on access to improved sanitation in many households (Yakubu et al. 2014).

HIV/AIDS is both a manifestation of poverty conditions and the result of the unmitigated impact of the epidemic on social and economic reasons (Mufune 2015). At global scale, empirical evidence indicates strong and significant associations between HIV prevalence and aspects of socio-economic performance. In general, the higher the level of HIV, the lower the level of economic growth, measured in terms of rate of growth per capita GDP and the proportion of the people living under US $1 per day (Nketiah et al. 2019). The lack of convenient and affordable access to water reduces a poor household's consumption of other commodities and services, leaves it consuming less than the optimum amount of water for good hygiene, and impacts health and labour productivity of the household members. It may also reduce income-generating opportunities of the household, thereby further reducing income and consumption. Hence, water supply and sanitation become key drivers of a reduction in inequality, enhanced health and well-being, economic growth and prosperity.

CHAPTER THREE: MATERIALS AND METHODS

3.1. Description of the Study Area

The research was carried out in Kasungu District in the Central region of Malawi (Figure 9). The district has a population of 842,95. The district covers an area of 7,878 Km^2 and is bordered by Zambia to the West, Mchinji district to the Southwest, Dowa and Lilongwe districts to the South, Ntchisi and Nkhotakota districts to the East, and Mzimba District to the North. Kasungu Manucipality is on grid reference 33º 30' east and 13º 03' south and about 127 kilometers North of Lilongwe, the capital city of Malawi. It is along the M1 Road running from Lilongwe to Mzuzu (Kasungu Urban socio-economic profile 1998). The district which is considered to be a child labor hot spot, has tobacco as the main income earner amongst people living in the rural areas (Makwinja 2010). The 1998 Integrated Household Survey indicates that 48,9% of the people in Kasungu live below the poverty line.

A quantitative cross-sectional study involving adults living with HIV in Kasungu District found that HIV was common among non-pregnant females (40.9%) compared to pregnant females, (19.3%). HIV was also more common among non-pregnant females than men (40.9% vs. 39.6%, respectively) (Yoon et al. 2018). Kasungu has five sanitation systems: toilets that discharge directly into a decentralised foul/separate sewer (5 percent); septic tanks connected to soak pits (18%); lined pits with semi-permeable walls and open bottoms and no outlet or overflow (5%); septic tanks connected to soak pits, where there is a significant risk of ground water pollution (1%); unlined pits with no outlet or overflow, where there is a low risk of groundwater pollution (66%) and open defecation (5%) (Water Aid 2019). Most of the portable water is supplied by a government statutory corporation- Central Region Water Board (CRWB), Kasungu zone. About 84% of residents in the township get their water from this board through taps. The remaining 16% get water from boreholes, springs and rainwater. According to the groundwater pollution risk decision matrix of the Shit Flow Diagram (SFD)

calculation tool, the groundwater pollution risk is considered low if the percentage of users drinking water produced from groundwater is between 1%-25%. Considering other parameters, the overall risk of ground water pollution is low (Water Aid 2019). Find below (Figure 6) the map depicting Kasungu District, the study area.

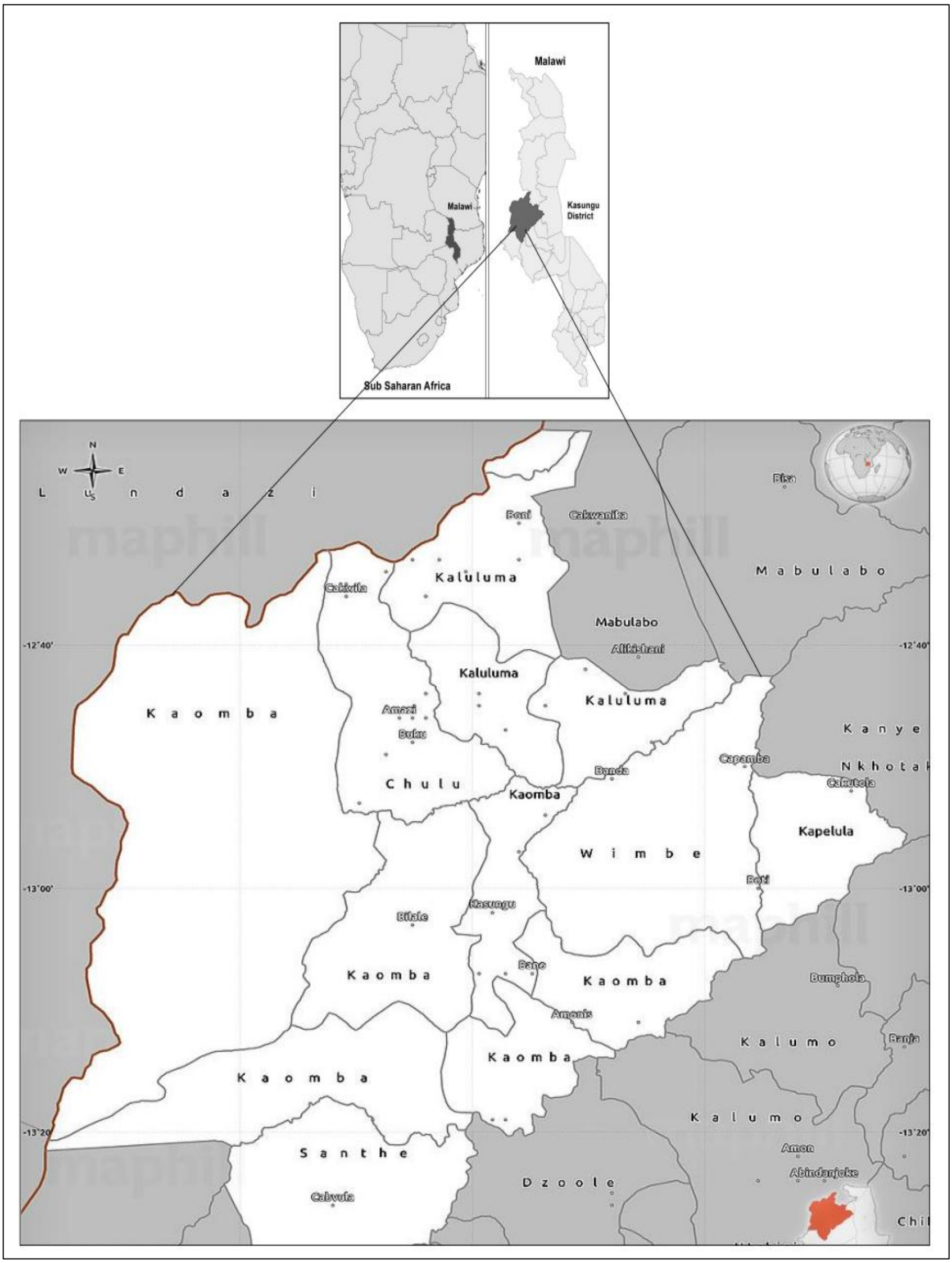

Figure 8: Map of Kasungu Malawi and the sub-Saharan Africa region

3.2. Research design

Using systematic random sampling, a quantitative cross-sectional study involving 293 HEIs aged between 6 weeks and 24 months was conducted in Kasungu, Central Malawi. The first study participant was randomly selected. However, next, every study participant was selected in the order of every K^{th} interval until the final sample size was reached.

A questionnaire survey was conveyed through Kobo Collect- an android-based application which fed into the Kobo Toolbox account. After a thorough training, all data collectors had their skills evaluated in a test of 10 practice observations to a selected few people who were not respondents in the study. If the Kappa Index (a test of agreement beyond chance) was greater than or equal to 80%, the data clerks received approval to take part. Those that did not meet the desired level of concordance had their training extended and re-evaluated before admission to participate as data collectors.

Every participant in the study had their poverty status determined to ascertain whether per-capita aggregate household consumption was below a given poverty line using the Malawi Simple Poverty Scorecard. A total of 10 verifiable low- cost indicators drawn from the 2016/17 Integrated Household Survey (IHS) were used to estimate the likelihood that a household has consumption that is below a given poverty line. The performance of the Simple Poverty Scorecard (shown in Table 4 below) was compared against the performance of established regression-based estimators. All estimates were benchmarked against observed poverty status based on household expenditure or income data from household socioeconomic surveys (Diamond et al. 2016).

Table 4: The Malawi Simple Poverty Scorecard (Schreiner, 2015).

Simple Poverty Scorecard® Poverty-Assessment Tool

			Name	Identifier
Interview ID:				
Interview date:		Participant:		
Country:	MWI	Field agent:		
Scorecard:	002	Service point:		
Sampling wgt.:			Number of household members:	

Indicator	Response	Points	Score
1. How many members does the household have?	A. Seven or more	0	
	B. Six	4	
	C. Five	10	
	D. Four	15	
	E. One, two, or three	31	
2. Is the (oldest) female head/spouse able to read and write in Chichewa or English?	A. No	0	
	B. Yes, only Chichewa	4	
	C. Yes, English (regardless of Chichewa)	8	
	D. No female head/spouse	13	
3. The floor of the main dwelling is predominantly made of what material?	A. Smoothed mud, or sand	0	
	B. Smooth cement, wood, tile, or other	8	
4. The outer walls of the main dwelling of the household are predominantly made of what material?	A. Mud (*yomata*), or grass	0	
	B. Mud brick (unfired)	5	
	C. Compacted earth (*yamdindo*), burnt bricks, concrete, wood, iron sheets, or other	8	
5. The roof of the main dwelling is predominantly made of what material?	A. Grass, plastic sheeting, or other	0	
	B. Iron sheets, clay tiles, or concrete	3	
6. What kind of toilet facility does the household use?	A. None, traditional latrine without roof shared with other households, or other	0	
	B. Traditional latrine without roof only for household members	4	
	C. Traditional latrine with roof shared with other households	4	
	D. Traditional latrine with roof only for household members, VIP latrine, or flush toilet	6	
7. What is the household's main source of lighting fuel?	A. Collected firewood, purchased firewood, grass, or gas	0	
	B. Paraffin, or other	8	
	C. Battery/dry cell (torch), candles, or electricity	13	
8. Do any members of the household sleep under a bed net to protect against mosquitos at some time during the year?	A. No	0	
	B. Yes	5	
9. Does the household own any tables?	A. No	0	
	B. Yes	9	
10. Does the household own any beds?	A. No	0	
	B. Yes	4	
SimplePovertyScorecard.com		Score:	

Table 5: Look-up Table to convert scores to poverty likelihood

(Schreiner, 2015)

If a household's score is . . .	. . . then the likelihood (%) of being below the poverty line is:
0–4	100.0
5–9	86.9
10–14	85.9
15–19	85.6
20–24	77.6
25–29	64.8
30–34	55.1
35–39	47.1
40–44	39.6
45–49	32.5
50–54	20.7
55–59	16.7
60–64	12.8
65–69	7.2
70–74	4.2
75–79	3.5
80–84	1.5
85–89	0.8
90–94	0.8
95–100	0.0

OBJECTIVE 1, 2 & 3: This was a quantitative, cross-sectional study. The study established the relationship between WaSH variables and child health expressed in terms of diarrhoea. Objective 3 and 4, and 5 the study employed a systematic review approach using secondary data. Hospital follow up data for HEI generated for a period of 24 months were reviewed to obtain biomedical data as follows:

a. All patient cards were gathered and categorized according to birth cohorts

b. All patient cards were checked for completeness of the following data:

- Identification data
- Parent contact details
- Consent to home follow-up visit
- Place and mode of delivery
- DNA/PCR result

- The first and second rapid antibody test result
- Adherence to Nevirapine prophylaxis in the first 6 weeks of life
- Adherence to Co-trimoxazole prophylaxis from 6 weeks to 24 months
- Outcome status

The same children were linked to their families or households (HH) using identification data. The outcome variable of this study was the prevalence of diarrhoea among children aged 0 – 24 months within the past 2 weeks preceding the survey. The interviewed women were asked whether their children who were under the age of 24 months had diarrhoea in the last 2 weeks. Explanatory (independent) variables included the following: (a) toilet location (b) toilet Category (c) fixed hand washing station, soap availability (d) sanitary condition of a latrine (e) access to drinking water supply. HH data on selected WaSH descriptors were obtained at home visits using a survey questionnaire. All HH were categorized based on poverty index using the Malawi simple Poverty scorecard to ascertain the number of HEI living in poverty. The scorecard used ten verifiable low- cost indicators drawn to estimate the likelihood that a household has consumption that is below a given poverty line.

WaSH descriptors (Sanitary type and condition of the latrine)

A sanitary inspection guided by the five sanitation descriptor elements based on the HHRR Normative Criteria and Flores Baquero et al. (2016) was conducted to characterize latrine quality. The elements included: (a) sanitary condition of the latrine, (b) general latrine design standards, (c) sanitation chain and management, (d) handwashing and (e) hygiene practices in the latrine. The latrine quality characterization was based on three service levels namely: Good level, Intermediate level and Poor level service. Information was also collected on other sanitation indicators namely: (a) availability and (b) physical accessibility of the latrine. Characterization of these two indicators were based on four ranked levels of quality: Good level, Intermediate level, Poor level service or No level of service as shown in Table 6.

Table 6: WaSH Descriptors and Characterization (Flores Baquero et al. 2016)

Household drinking water services

Service Level	Definition
Safely managed	Drinking water from an improved water source which is located on premises, available when needed and free of fecal or microbial contamination
Basic	Drinking water from an improved water source provided collection time is not more than 30 minutes for a round trip including queuing
Limited	Drinking water from an improved source where collection time exceeds over 30 minutes for a round trip to collect water, including queuing
Unimproved	Drinking water from unprotected dug well or unimproved spring
No service	Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

Table 7: WaSH Descriptors and Characterization (Flores Baquero et al. 2016)

Sanitation services

Service Level	Definition
Sanitary Condition	
Good level of service	No insects, no smell, adequately clean
Intermediate level of service	Few insects, slight unpleasant smell, some dirt but no faeces or urine
Poor level of service	Insects, strong unpleasant smell, faces or urine on the floor
Latrine design standard	
Good level of service	Lined pit, undamaged superstructure
Intermediate level of service	Inadequate lining of the pit and damaged superstructure
Poor level of service	No lined pit, no superstructure
Sanitation chain and management	
Good level of service	Safe disposal of excreta in situ or treated offsite
Intermediate level of service	Safe removal and transportation of excreta offsite with no treatment
Poor level of service	Unsafe emptying/transportation, inadequate containment of excreta

Table 8: WaSH Descriptors and Characterization (Flores Baquero et al. 2016)

Hygiene services

Service Level	Definition
Handwashing	
Good level of service	Handwashing facility with water and soap/ash
Intermediate level of service	Handwashing facility with no soap/ash
Poor level of service	No handwashing facility
Hygiene practices in the latrine	
Good level of service	Availability of water and cleansing materials; adequate menstrual hygiene management; hygienic disposal of cleansing and menstrual products
Intermediate level of service	Acceptable hygienic practices
Poor level of service	No water/cleansing materials; inadequate menstrual hygiene management; unhygienic disposal of cleansing and menstrual products

OBJECTIVE 3: The added effect of co-trimoxazole prophylaxis and improved WaSH interventions on diarrhea among HEI and PLWHA

Answers to this research question were achieved in two ways. The relevance of best biomedical practice and non-adherence to the same was expressed through odds of diarrhoea. Biomedical practices were expressed in terms of infant feeding habits, uptake of NVP and co-trimoxazole against the risk of diarrhoea. Primary data were involved to make inferentials about HEI by employing quantitative techniques (hypothesis testing and confidence intervals).

The second approach was through a systematic review of the 'review question'. This systematic review followed guidelines developed by the PROSPERO for systematic search and selection. PROSPERO is an international database for registering systematic reviews in various professions including the health sector (Page et al. 2018). The protocol was published in the PROSPERO database with registration number CRD42021240512. Details about the protocol have been published elsewhere (https://www.crd.york.ac.uk/prospero/#myprospero). PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram was used to show the number of articles retrieved, retained, excluded with justifications rendered for every action. A PRISMA is a set of items founded on research evidence that improves and supports the reporting clarity of the systematic reviews and meta-analyses (Moher et al. 2009). A Mixed Method Appraisal Tool (MMAT) was used to appraise the quality of the studies included. Eligible studies fulfilled the following criteria: studies involving morbidity and mortality of PLWHA and HEI; studies aimed at identifying an added effect of safe water supply on frequency and severity of diarrhoea among HEI and PLWHA who are routinely taking co-trimoxazole prophylaxis. Articles were excluded from this systematic for the following reasons:

a. Reviews, perspectives, communications
b. Written in languages other than English.

The following seven database sources were used to gather the required research articles:

a. PubMed
b. EMBASE
c. PsycINFO
d. AMED
e. CINAHL
f. DOAJ

g. Google Scholar

h. PubMed

Keywords combined with Boolean operations OR and AND were used to search and retrieve articles from the databases. The search period for the research articles in the mentioned databases started from February 2002 to February 2022 covering a period of 20 years. The following key search words/terms were used; safe sanitation AND/OR improved water supply AND/OR WaSH AND/OR co-trimoxazole prophylaxis AND/OR HIV-exposed AND/OR PLWHA AND/OR morbidity AND/OR mortality AND/OR diarrhea. The study used a data extraction table shown in table 13 to accumulate data that is useful to the systematic review question: *What is the combined effect of co-trimoxazole prophylaxis and improved WaSH interventions on diarrhea among HEI and PLWHA?* Since a systematic review involves combining studies relevant to a specific research question, the data extraction table contained information about these studies. For example, the type of study used in the systematic review, be it a random controlled trial, a cohort study, or a case-control study. The MMAT tool in table 14 was used to appraise the quality of different study designs focusing on methodological criteria. The search strategy combined all the key concepts for this research question in order to retrieve accurate results as shown in Table 7 below.

Table 9: Search Strategy (1)

Databases	Search	Search word/terms	Results
PubMed	Title and abstract	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	1
EMBASE	Title, abstract and full article	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	0
PsycINFO	Title, abstract and full article	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	1
AMED	Title and abstract	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	0
CINAHL	Title and abstract	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	0
DOAJ	Title, abstract and full article	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	0
Google Scholar	Title, abstract and full article	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	6
Reference search from other sources	Title, abstract and full article	Improved water supply OR poor sanitation AND/OR WaSH AND/OR biomedical OR co-trimoxazole preventive therapy, AND HIV-exposed OR PLWHA, OR HIV unexposed uninfected OR HIV infected OR HIV/AIDS AND morbidity OR mortality OR diarrhoea.	0
	Total Result Search		**8**

Study Selection

Articles identified from the databases were imported to Mendeley Reference Management Software. Thereafter, the title, abstract and finally full articles were reviewed against the set inclusion criteria. The process of data extraction started with a database search of relevant articles as described above and following the PRISMA guidelines (see Figure 2). Titles and/or abstracts of studies were retrieved and studies that potentially met the inclusion criteria as outlined above were identified. The full texts of potentially eligible studies were retrieved and independently assessed for eligibility by two authors. The inconsistencies between the two authors (EC and BM) over the eligibility of some studies were discussed and resolved with a third author (WS) or (RC). A table was used to extract data from the studies included for assessment of study quality and synthesis evidence. The details included author, year of study, type of participants, age, setting, country, sample size, study design and methods, study purpose/objectives, study outcomes and results. All relevant information was extracted from each study, summarized and documented.

An initial search of the databases and other sources yielded 1055 articles. Only 321 articles were left after removal of duplicates. The remaining articles were further filtered, and 292 articles were excluded because they were either abstracts only or they contained a totally different study topic. All full-text articles were further assessed for eligibility and 21 articles were dropped because they lacked sufficient details for the intended study. The remaining 8 articles were selected for the final analysis (See Figure 7).

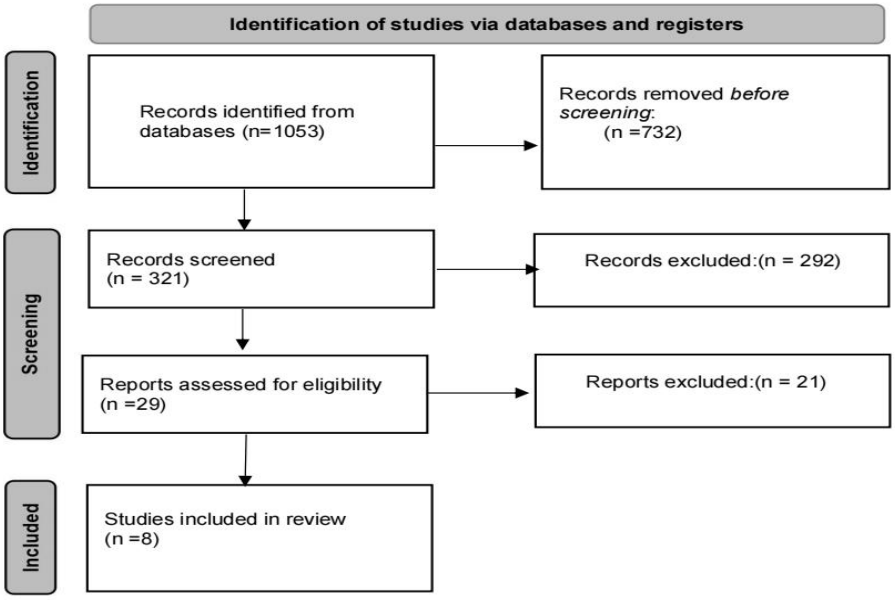

Figure 9: The PRISMA Flow diagram (1)

OBJECTIVE 4: The effect of improved WaSH on linear growth

The study used a data extraction Table 15 to accumulate data that is useful to the systematic review question. The question that this systematic review tries to resolve is "What is the effect of improved water supply and sanitation on linear growth among children aged 0-59 months?" The key outcome of the review was "LAZ -2 SD" at 59 months. Additional outcomes were "underweight" (weight-for-age) and "wasting" (weight-for-height), based on the WHO 2006 Child Growth Standard. The MMAT tool in table 16 was used to appraise the quality of different study designs focusing on methodological criteria. PubMed, EMBASE, PsycINFO, AMED, CINAHL, DOAJ and Google Scholar search was performed. The search period was set from the period starting from January 2012 to December 2021 covering a period of 9 years. The following search terms were used; sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction.

We hypothesized that if linear growth failure is multifaceted, observance to WaSH practices alone may not reduce the odds of stunting. The question that this systematic review tries to

resolve is “What is the effect of improved water supply and sanitation on linear growth among children aged 0-59 months?” The key outcome of the review was “LAZ -2 SD” at 59 months. Additional outcomes were “underweight” (weight-for-age) and “wasting” (weight-for-height), based on the WHO 2006 Child Growth Standard. To improve the clarity of reporting, we summarized the article screening process using an evidence-based minimum set of items. As propagated by Moher et al. (2009), the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram is designed to enhance transparent reporting and justification for every action taken by systematic reviewers. A Mixed Method Appraisal Tool (MMAT) was used to critically appraise the methodological quality of all the selected studies. We considered RCT and CRCT study designs, studies involving children with stunted growth, environmental enteric dysfunction and studies on water supply, sanitation and child health.

Articles were excluded from this systematic for the following reasons:

a. Reviews, perspectives, communications
b. Written in languages other than English.
c. From developed countries

The following seven database sources were used to gather the required research articles:

a. PubMed
b. EMBASE
c. PsycINFO
d. AMED
e. CINAHL
f. DOAJ
g. Google Scholar
h. PubMed

The search period was set from the period starting from January 2012 to December 2021 covering a period of 9 years. The following search terms were used; sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction. An effort was made to manually extract both published and unpublished interventional studies and hand searching key journals (See Table 8).

Table 10: Search strategy (2)

Databases	Search	Search word/terms	Results
PubMed	Title and abstract	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	2
EMBASE	Title, abstract and full article	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	0
PsycINFO	Title, abstract and full article	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	1
AMED	Title and abstract	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	0
CINAHL	Title and abstract	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	0
DOAJ	Title, abstract and full article	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	1
Google Scholar	Title, abstract and full article	sanitation OR improved water supply AND/OR WaSH AND/OR stunting, AND/OR linear growth, AND/OR environmental enteric dysfunction	10
Reference search from other sources	Title, abstract and full article		0
	Total Result Search		**14**

Identified articles were imported to Mendeley desktop window before they could be reviewed against the set inclusion criteria. Using non-automated data extraction method, we collected data of outcomes of interest for each participant in the same manner using a well-defined instrument. In this manner, information from multiple studies that have investigated the same thing, was gathered. Potential studies were identified and assessed for eligibility by two authors and where discordant opinions arose, the third author resolved the tie. All relevant information was extracted from each study, summarized and documented. The data extraction table detailed the following information: author, year of study, type of participants, age, setting, country, sample size, study design and methods, study purpose/objectives, study outcomes and results. An initial database search located 2103 articles. A total of 441 articles were left after removal of duplicates. The remaining articles were further filtered and 427 articles were excluded because of age bracket (256), inappropriate outcome measures (150) and studies from developed countries (21). The remaining 14 articles were selected for the final review (See Figure 8).

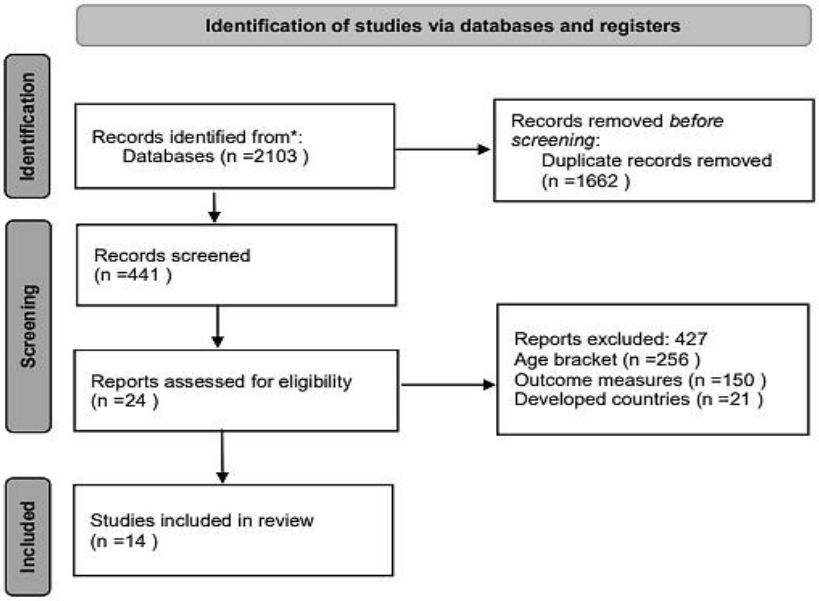

Figure 10: The PRISMA Flow Diagram (2)

OBJECTIVE 5: The effect of helminth infections on HIV disease progression among helminth/HIV-1 co-infected persons

We hypothesized that pre-existing helminths infestations may lead to impaired immune control of HIV-1, resulting in escalating HIV-1 viral loads and reduced levels of CD4+ T-lymphocyte count and higher likelihood of vertical HIV-1 transmission.

We considered studies involving helminth co-infection among HIV-1 infected persons. All included studies were from Africa and involved HIV-1 infected persons who were recently treated for helminthiasis, or had a laboratory confirmed diagnosis of helminthiasis.

Articles were excluded from this systematic for the following reasons:

a. Reviews, perspectives, communications
b. Written in languages other than English.
c. From developed countries
d. Without a laboratory confirmed diagnosis of helminthiasis.

The following seven database sources were used to gather the required research articles:

a. PubMed
b. EMBASE
c. PsycINFO
d. AMED
e. CINAHL
f. DOAJ
g. Google Scholar
h. PubMed

The search period was set from the period starting from

The search period was set from the period starting from January 2010 to December 2022, covering a period of 12 years. The following search terms were used; helminths AND/OR

Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression. An effort was made to manually extract both published and unpublished interventional studies and hand search key journals. The Mixed Methods Appraisal Tool (MMAT) was used to appraise the selected studies. MMAT is a validated checklist used to appraise the quality of studies included in any systematic review with a quantitative, qualitative and mixed methods approach (See Table 9).

Table 11: Search Strategy (3)

Database	Search	Search word/terms	Results
PubMed	Title abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
EMBASE	Title, abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
PsycINFO	Title, abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
AMED	Title and abstract	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
CINAHL	Title and abstract	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
DOAJ	Title, abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
Google Scholar	Title, abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	10
Reference search from other sources	Title, abstract and full article	helminths AND/OR Water, Sanitation and Hygiene AND/OR WaSH AND/OR HIV/AIDS AND/OR CD4+ count AND/OR HIV-1 RNA AND/OR Viral load AND/OR HIV disease progression	0
	Total Result Search		**10**

Identified articles were imported to Mendeley desktop window before they could be reviewed against the set inclusion criteria. Titles and/or abstracts of studies were retrieved using the search strategy to identify studies that potentially met the inclusion criteria stated above. A standardized form was be used to extract data from the included studies for quality and.evidence synthesis. The details will include: Author, year of study, type of participants, age, setting, country, sample size, study design, and methods, study purpose and objectives, study outcome measures. Four review authors extracted data independently; discrepancies were tabled for discussion. An initial database search located 2032 articles. A total of 432 articles were left after the removal of duplicates. The remaining articles were further filtered, and 427 articles were excluded because of age bracket (256), inappropriate outcome measures (299), and studies from non-African countries (123). The remaining 10 articles were selected for the final review (See Figure 9).

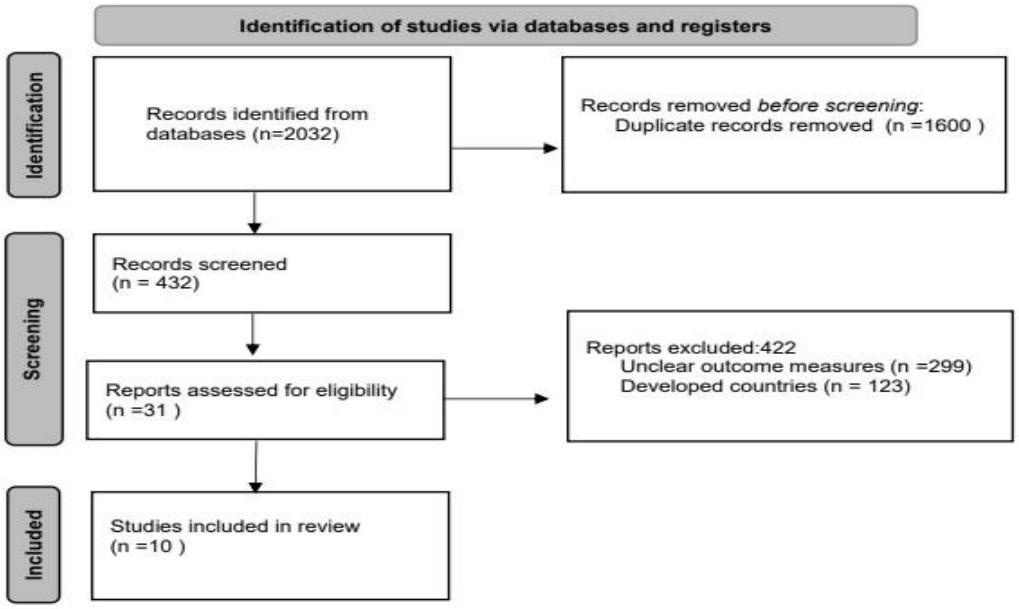

Figure 11: The PRISMA Flow Diagram (3)

Table 12: Data Collection and Analysis Matrix

S/N	Objectives	Type of Data and Methods	Variables	Sampling Technique	Strategy for Answering Research Question	Analysis Method
1	To estimate the effect of socio-demographic characteristics on diarrhea among HEI.	Quantitative – Questionnaire, Interviews	• Self-reported diarrhea • Socio-demographic data	Systematic random sampling	Quantitative-correlational	Binary Logistic regression
2	To establish the influence of WaSH descriptors on diarrhoea among HEI.	Quantitative – Questionnaire, Interviews	• Self-reported diarrhea • Sanitation descriptors	Systematic random sampling	Quantitative-correlational	Multivariate logistic regression
3	To determine the added effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis.	Secondary data	• Self-reported diarrhea • Infant feeding • Co-trim/NVP	Eight studies retrieved from AMED, CINAHL, DOAJ, PubMed, PsycINFO, Google Scholar, and EMBASE databases	Quantitative-correlational Systematic review	Multivariate logistic regression & Narrative Synthesis

4	To determine the effect of improved WaSH on linear growth trajectory.	Secondary data	• LAZ -2 SD	Fourteen studies retrieved from AMED, CINAHL, DOAJ, PubMed, PsycINFO, Google Scholar, and EMBASE databases	Systematic review	Narrative Synthesis
5	To evaluate the effect of helminth infections on HIV disease progression among helminth-HIV-1 co-infected persons.	Secondary data	• Plasma HIV-1 RNA Viral load (V/L) • Cluster of Differentiation (CD4+) T-lymphocyte count	Ten studies retrieved from AMED, CINAHL, DOAJ, PubMed, PsycINFO, Google Scholar, and EMBASE databases	Systematic review	Narrative Synthesis

3.3. Sampling framework and methods

Figure 11 details the sample size determination. This study focussed on the whole Kasungu District. All health 14 facilities that are certified to register, treat and follow up HIV exposed infants were targeted. The District health Office HMIS was the entry point of access to the integrated register for all HEI who were currently receiving care and support from the District. Using this approach as detailed in the figure 11 below, all sites were given an equal chance to participate in the survey. Sample size determination using Slovin's formula was only applied after rigorous identification and screening phases. A systematic random sampling technique was used to sample the target population of HEI. The total number of eligible participants population was 899 HEI. The K^{th} value for the study was computed as follows: K= 899/301=2.9 (rounded to 3). Then, the first study participant was selected using the lottery method. That means among clinic attendants at the period of sampling, the first study participant was selected using simple random technique. However, next, every study participant was selected in the order of every K^{th} interval. The predetermined K^{th} or fixed sampling interval of 3 was performed until the final sample size was reached. The inclusion and exclusion criteria have been laid out in Figure 12 below.

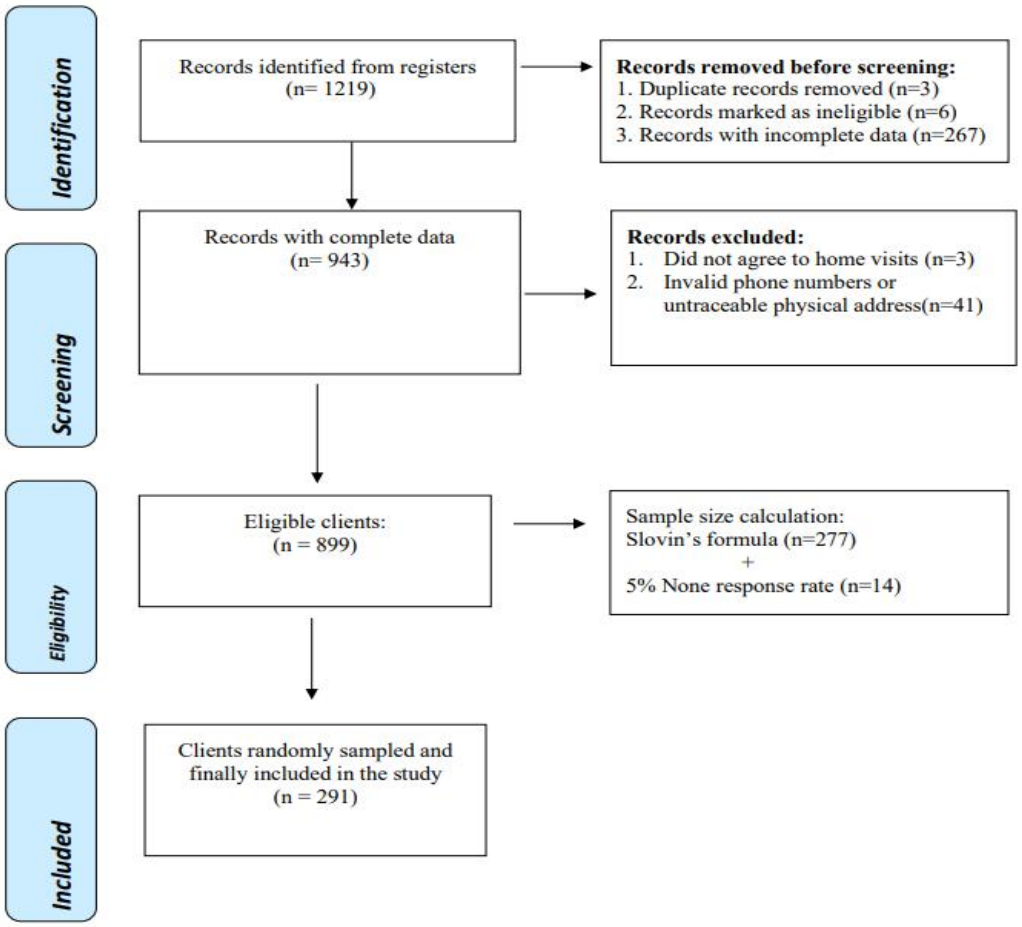

Figure 12: Schematic Presentation-The inclusion and exclusion criteria

3.3.1. Sample size

The sample size was generated using Slovin's (1960) formula. With regard to the level of accuracy, a confidence level of 95% as suggested by Kothari (2005), this means that there are 95 chances in 100 (or .95 in 1) that the sample results represent the true condition of the population within a specified precision range against 5 chances in 100 (or .05 in 1) that it does not.

Slovin's formula (1960)

$$n = \frac{N}{1 + N * (e)^2}$$

Where;

n is the sample size

N is the population size

e is the acceptable sampling error

The total number of eligible participants population was 899 HEI. Sampling error was set at 5%, and then the sample size was calculated as follows:

n=899/1+899(0.05*0.05)

n=277

None response rate (5%) 14

14+277=291

*However, the actual number that was available and participated in the study was 293.

3.4. Data Collection

A questionnaire survey was conveyed through Kobo Collect- an android-based application which fed into the Kobo Toolbox account. After a thorough three-hour training, all data collectors had their skills ascertained using Kappa Index before they could be approved to undertake the task. If the Kappa Index (a test of agreement beyond chance or skills score) was greater than or equal to 80%, the data clerks received approval to take part. Those that did not meet the desired level of concordance had their training extended and re-evaluated before admission to participate as data collectors. Individual patient records for HEI were systematically reviewed. Quantitative interviews were conducted at HH level (Refer to Table 10 Research design, data collection and analysis matrix).

3.5. Data Management and Statistical Analysis

(Refer to Table 10 Research design, data collection and analysis matrix)

3.5.1. Primary Data

Data were analyzed using IBM Statistical Package for Social Scientist (SPSS) Version 25. Descriptive statistics were used to analyze social demographic household WaSH characteristics.

For objective 1, binary logistic regression analysis (Osborne 2017) was used to estimate the association between the outcome variable (diarrhoea) and the following explanatory variables:

Caregiver's age, ethnicity, marital status, educational level, and employment status.

For objective 2, binary logistic regression analysis was used to estimate the association between diarrhoea and the following explanatory variables: Toilet location, Toilet category, Fixed handwashing station, Availability of soap, The sanitary condition of the latrine and Access to drinking water supply

For Objectives 1 and 2:

The $\chi 2$ test was applied to determine whether there was a significant difference between variables with significance level of 0.05. Explanatory variables that had a *p*-value lower than 0.05 in the initial logistic analysis were included in a new logistic regression model. In this model, the variables were chosen using backward Wald method with significance level of 0.05 and 95% CI to analyze the determinant of child diarrhoea. A logistic regression was performed to ascertain the combined influence of socio-demographic characteristics and WaSH descriptors on prevalence of diarrhoea. The logistic regression model was statistically significant, χ^2 (8) = 148.066, $p < .0005$. The model explained 62.4% (Nagelkerke R^2) of the variance in diarrhoea and correctly classified 85.5% of cases (See Table 11, 12 and 13 in the results section).

3.5.2. Secondary Data

For objectives 3, 4, and 5

Identified articles were imported to Mendeley desktop window before they could be reviewed against the set inclusion criteria. Titles and/or abstracts of studies were retrieved using the search strategy to identify studies that potentially met the inclusion criteria stated above. A standardized form (data extraction table) was be used to extract data from the included studies for quality and evidence synthesis. The details included: Author, year of study, type of participants, age, setting, country, sample size, study design, and methods, study purpose and objectives, study outcome measures (Table 16, 18 and 20). A Mixed Methods Appraisal

Tool (MMAT) was used to appraise the selected studies. MMAT is a validated checklist used to appraise the quality of studies included in any systematic review with a quantitative, qualitative and mixed methods approach (Hong et al. 2018), (Refer to Table 17, 19 and 21).

CHAPTER FOUR: RESULTS

4.1. Introduction

The primary outcome of the study was the occurrence of any diarrhoea. The research aimed to establish the influence of independent (predictor variables) on the likelihood of acquiring diarrhoea among HEI. The predictor variables were (a) Socio-demographics (caregiver's age, ethnicity, marital status, floor and roofing material, educational level, employment status); (b) Sanitation descriptors (latrine/toilet availability, accessibility, quality and user safety); (c) water service ladder (drinking water source and its quality and time/distance for a round trip); (d) Hygiene behavior (hygiene practices in the latrine, availability of hand-washing facility and soap in the vicinity of the latrine). All participants in this study were taking co-trimoxazole prophylaxis from the age of 6 weeks to 24 months. This chapter contains detailed presentation of the results of this study. The findings are presented under the following sub-headings:

a) To estimate the effect of socio-demographic characteristics on diarrhea among HEI.
b) To establish the influence of WaSH descriptors on diarrhoea among HEI.
c) To determine the added effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis.
d) To determine the effect of improved WaSH on linear growth trajectory.
e) To evaluate the effect of helminth infections on HIV disease progression among helminth-HIV-1 co-infected infants.

4.1.1. Effect of socio-demographic characteristics on diarrhoea among HEI

The causal relationship between social-demographic characteristics and diarrhoea revealed several noteworthy findings. HEI from mothers who were aged between 25-34 years had a slightly higher risk of diarrhoea than those aged 15-24 years, although this difference was not statistically significant. Infants whose mothers where aged 35 years and older had a lower risk of developing diarrhoea than the reference group (15-24 years old), with an adjusted odds ratio (AOR) of 0.79 (95% CI: 0.38-1.61). Regarding ethnicity, the findings revealed no significant variations in diarrhoea prevalence between the Chewa, Tumbuka, and Yao ethnic groups and a designated 'Other' category. Marital status exhibited significant relationships with diarrhoea prevalence. HEI whose mothers were married had considerably higher risk of suffering diarrhoea than single individuals (AOR: 3.64, 95% CI: 1.85-7.19), and widowed persons had an increased risk as well, though not statistically significant. Divorced people had a reduced risk of diarrhoea than the reference group. Participants whose mothers had secondary or tertiary education had significantly greater risks of diarrhoea than those without formal education, with AORs of 2.22 (95% CI: 1.18-4.20) and 9.72 (95% CI: 4.11-22.96), respectively. The chances were substantially higher for individuals with primary education (AOR: 9.39, 95% CI: 2.58-34.14). HEI whose mothers were self-employed, had a greater risk of acquiring diarrhoea than their counterparts from the formally employed mothers (AOR: 2.46 (95% CI: 1.22-4.93). The odds were significantly higher for infants whose mothers were unemployed (AOR: 16.76, 95% CI: 2.19-128.41).

Table 13: Socio-demographic influencing factors of diarrhoea among HEI

Independent Variables (Social-Demographics)	Dependent Variable (With 95% CI) Diarrhoea Prevalence	
	COR	**AOR**
Age		
15-24 years old	1	1
25-34 years old	1.07 (0.43-2.65)	NA
≥35 years old	0.79 (0.38-1.61)	NA
Ethnicity		
Chewa	1	1
Tumbuka	0.97 (0.35-2.74)	0.99 (0.43-2.29)
Yao	1.36 (0.27-6.80)	1.88 (0.52-6.77)
Other (Specify)	2.06 (0.35-11.97)	2.29 (0.511-10.28)
Marital status		
Married	1	1
Single	2.12 (0.92-4.89)	3.64 (1.85-7.19) **
Widow	3.30 (0.76-14.39)	5.68 (1.64-19.63) **
Divorced	0.57 (0.15-2.20)	0.38 (0.13-1.13)
Education Level		
Primary school	1	1
Secondary school	9.39 (2.58-34.14)**	2.22 (1.18 –4.20)*
Tertiary	31.75 (7.52-134.11)**	9.72 (4.11-22.96)**
No formal school	NA	NA
Employment status?		
Employed	1	1
Self-employed	1.98 (0.22-17.63)	16.76 (2.19-
Unemployed	2.46 (1.22-4.93)*	128.41)**
Retired	NA	3.67 (1.96 -6.86)**
		NA

4.1.2. The influence of WaSH descriptors on diarrhoea among HEI (Descriptive Analysis)

The following variables were considered herein described as WaSH descriptors: toilet location, toilet category, fixed handwashing station and availability of soap, the sanitary condition of the latrine and access to drinking water supply (Table 12). The study sought to establish the influence of these variables on the prevalence of diarrhoea and other WaSH-related diseases. Figures 12,13,14,15,16 show sanitary descriptors and their frequencies.

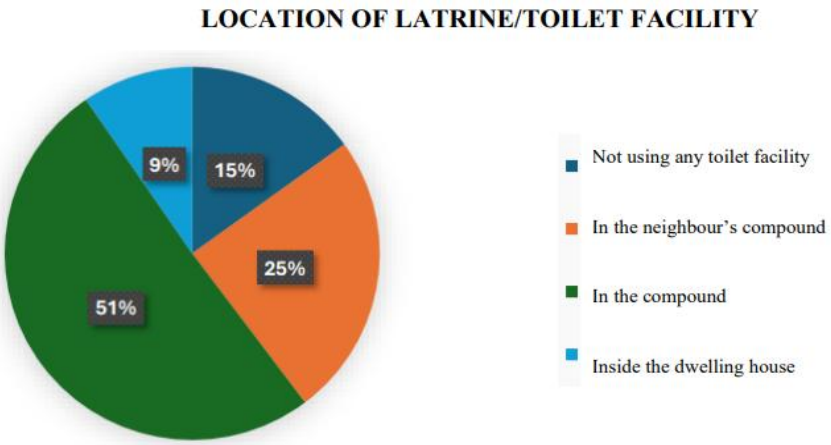

Figure 13: Toilet Location

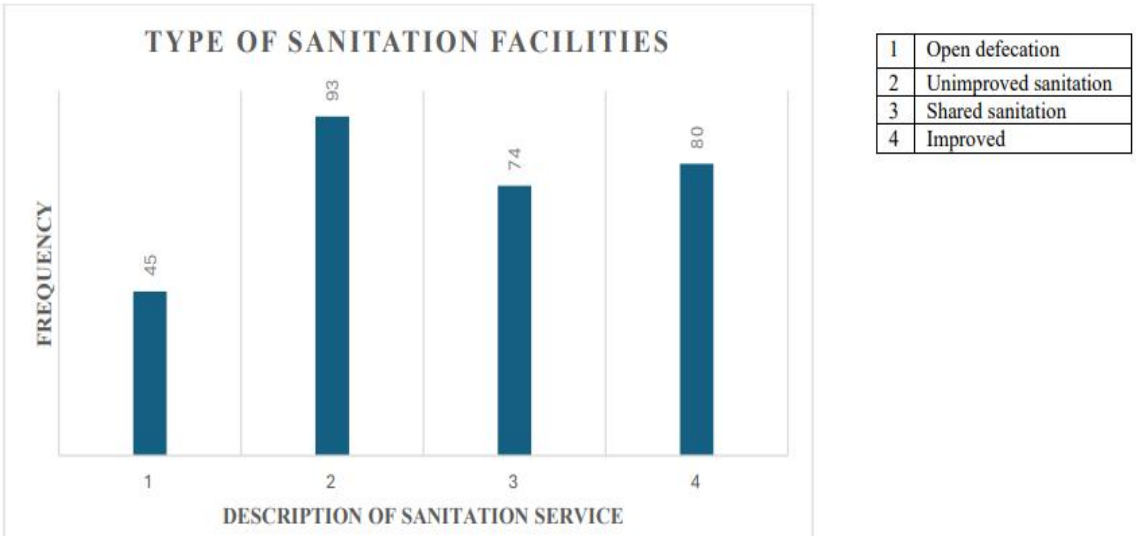

Figure 14: Sanitary Descriptors and their Frequencies

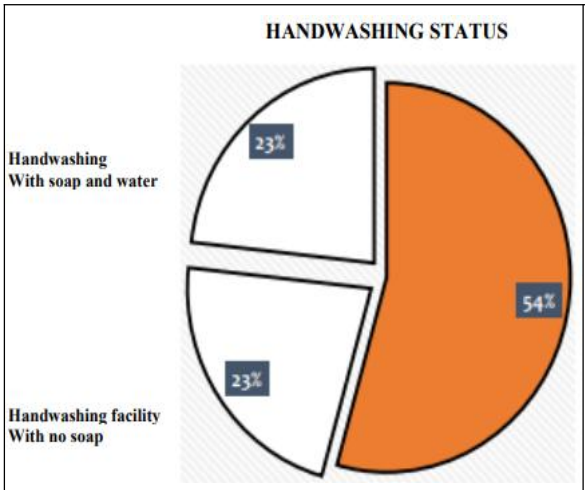

Figure 15: Handwashing Status

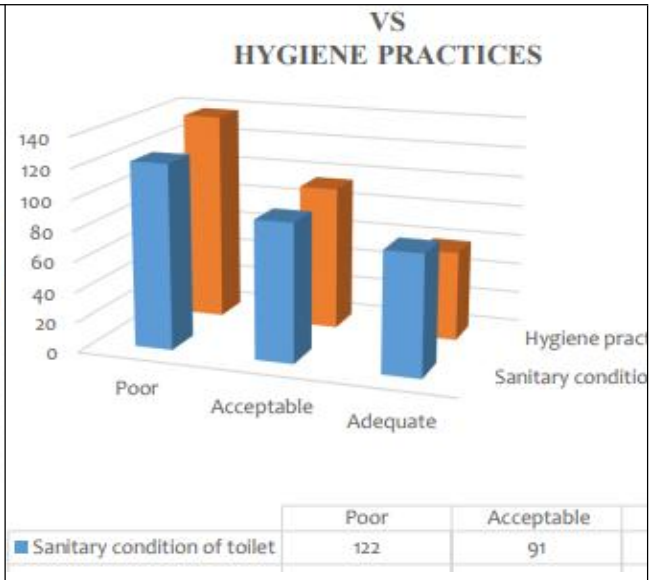

Figure 16: Sanitary Condition of Toilet and Hygiene Practices

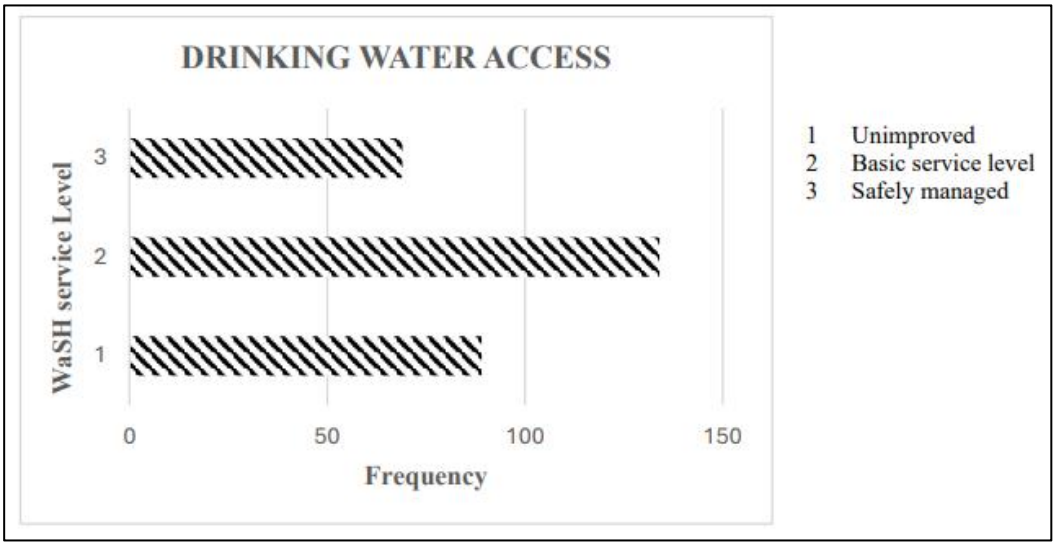

Figure 17: Drinking Water Supply and Access

4.1.3. The influence of WaSH descriptors on diarrhoea among HEI (Logistic Regression)

The findings revealed that households with limited-service level access had significantly greater chances of diarrhoea prevalence than those with safely managed access (AOR: 8.78, 95% CI: 4.58-16.83). Similarly, households with basic service level access had higher risks

of diarrhoea than those with properly managed access (AOR: 7.56, 95% CI: 3.30-17.33). These findings show the importance of safe and consistent drinking water availability in lowering the incidence of diarrheal diseases, emphasizing the need for enhanced water infrastructure and quality assurance procedures. In terms of family sanitation status, households whose sanitation had deteriorated had considerably greater odds of diarrheal prevalence than those where sanitation had remained relatively stable (AOR: 6.17, 95% confidence interval: 2.60-14.64). This underlines the significance of maintaining and enhancing sanitation facilities to prevent the spread of diarrheal infections within the home. In contrast, homes with considerably improved sanitation did not show a significant difference in diarrhoea prevalence compared to those with the same sanitation status, indicating that even little improvements in sanitation infrastructure can have major health advantages. In terms of hygiene, households with poor levels of service had significantly greater chances of diarrhoea prevalence than those with good levels of service (AOR: 12.64, 95% confidence interval: 6.24-25.61). Similarly, households with intermediate levels of service had higher chances of diarrhoea than those with strong levels of service (AOR: 7.31, 95% CI: 3.61-14.82). These findings emphasize the crucial relevance of promoting and maintaining good hygiene standards in homes to avoid diarrheal diseases, as well as the need for comprehensive hygiene education and behaviour modification programs.

Table 14: The influence of WaSH Descriptors on diarrhoea

Independent Variables	**Dependent Variable (With 95% CI)**	
WASH Descriptors	**Diarrhoea Prevalence**	
	COR	**AOR**
Household's access to drinking water supply		
Safely managed	1	1
Basic service level	11.56 (3.49-38.24)**	14.38 (6.51-31.75)**
Limited-service level	7.56 (3.30-17.33)**	8.78 (4.58-16.83)**
Family sanitation status		
Much the same	1	1
Much improved	3.11 (0.13-0.75)**	1.86 (1.02-3.36)*
Has become worse	0.86 (0.27-2.69)	6.17 (2.60-14.64)**
Hygiene Level		
Good level of service	1	1
Intermediate level of service	2.77 (0.94-8.14)	7.31 (3.61-14.82)**
poor level of service	8.95 (3.72-21.57)**	12.64 (6.24-25.61)**

*p<0.05, **p<0.01 NA p>0.25

4.1.4. The Context of Poverty Likelihood among HEI

The Poverty likelihood "look-up table" was used to convert the score to a likelihood of the respondent's household being below the poverty line. This poverty status of every household where an HEI lived is shown in Figure 17. They represent an average of 41% likelihood of living below the established poverty line. People living below a poverty line did not have enough to meet their basic needs including proper WaSH as they typically lived below extreme poverty line of $1.90 per day.

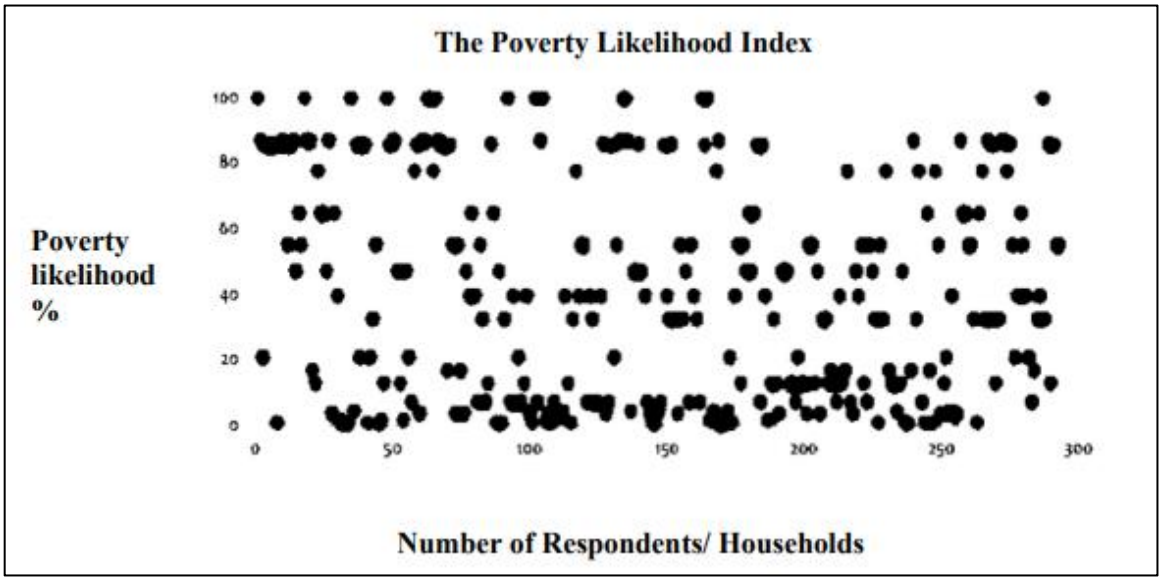

Figure 18: The Poverty Likelihood Index

4.1.5. The Relationship Between Adherence to NVP, CPT and Diarrhoea

The relationship between adherence to good drug practices and diarrhoea prevalence in children had the following results: In terms of adherence to Nevirapine prophylaxis, children with good adherence had significantly greater odds of diarrhoea than those with poor adherence (AOR: 6.87, 95% CI: 1.30-36.24), whereas the odds were not statistically different for those with uncertain adherence. Similarly, adherence to CPT (Cotrimoxazole Preventive Therapy) did not significantly correlate with diarrhoea prevalence.

In terms of infant feeding habits, exclusive breastfeeding was associated with a non-significant increase in the risk of diarrhoea when compared to replacement feeding, although the difference was not statistically significant. Infants who were exclusively breastfed had a higher but non-significant risk of diarrhoea than those who received replacement feeding (AOR: 4.34, 95% CI: 0.39-48.71). Furthermore, mixed and complementary feeding had non-significant relationships with diarrhoea prevalence compared to replacement feeding, with odds ratios of 2.00 (95% CI: 0.17-23.44) and 0.40 (95% CI: 0.02-10.02), respectively.

Table 15: The Relationship Between Adherence to NVP, CPT and Diarrhoea

Independent Variables Adherence To Good Practices and Medications	Dependent Variable (With 95% CI) Diarrhoea Prevalence	
	COR	**AOR**
Child's adherence to Nevirapine prophylaxis		
Good adherence	1	1
Poor adherence	7.39 (0.68-80.13)	6.87 (1.30-36.24)*
Unknown (No documentation)	1.47 (0.10-21.16)	0.63 (0.10-3.92)
Child's adherence to CPT		
Good adherence	1	1
Poor adherence	NA	NA
Unknown (No documentation)	NA	NA
Infant feeding practice		
Exclusive breastfeeding	1	1
Mixed feeding	3.79 (0.26-55.73)	4.34 (0.39-48.71)
Complementary feeding	3.57 (0.22-57.18)	2.00 (0.17-23.44)
Replacement feeding	0.22 (0.01 -6.70)	0.40 (0.02 -10.02)

The added effect of co-trimoxazole prophylaxis and improved WaSH interventions on diarrhea among HEI and PLWHA

Table 16: Data Extraction Table 1

Author & year	Population: Participants	Population: Age	Population: Setting	Country	Sample size	Study design & methods	Objectives/aims: Study purpose/ Objective	Objectives/aims: Outcomes	Results
Prendergast et al. 2018	HIV exposed infants HIV unexposed HIV positive pregnant and breastfeeding women Some children whose HIV status is not known	Children and adults	community	Zimbabwe	1394	Cluster Randomized controlled trial	To test the effect of improved infant and young child feeding (IYCF) and improved water, sanitation, and hygiene (WASH) on child linear growth and haemoglobin concentrations.	Reduced morbidity Inconsistent reductions in diarrhea	2% of children in the WaSH groups were stunted and wasted compared to the non-WaSH groups (absolute difference 0%; 95% CI −2 to 3). Safe water was associated with reductions in child diarrhoea
Rachel Paletz (Paletz et al. 2012)	HIV exposed infants and Non exposed infants	< 2 years	Household	Chongwe district, Zambia	1138	Randomized controlled field trial	To assess beneficial effects water filtration and safe storage in households caring for HIV exposed infants	Reduced morbidity Reduced diarrhoea	Safe water was associated with reductions in the longitudinal prevalence of reported diarrhea of 53% among children ,2 years (LPR = 0.47, 95% CI: 0.30–0.73, p = 0.001) and 54% among all household members (LPR = 0.46, 95% CI: 0.30–0.70, p,0.001).
Ezra J. Barzilay (Barzilay et al. 2011	HIV infected women	Not indicated	Household	Lagos, Nigeria	187	Randomized controlled trial	To evaluate the impact of point of use water quality interventions	Reduced morbidity Reduced diarrhoea	Significant diarrhea reduction among persons who did not take co-trimoxazole prophylaxis (-62%, p = 0.02). Point of use water treatment was associated with a reduced risk of diarrhea in PLWHA. Regular water treatment was required to achieve health benefits

Jiayin Xue **(Jiayin Xue et al. 2010)**	Mothers to HIV exposed infants	Women of childbearing age	Household	Lilongwe, Malawi	474	Prospective observational study	To evaluate a pilot prevention of mother-to-child transmission post-natal programme in Lilongwe, Malawi, through observed retention and infant diarrhoeal rates.	Reduced morbidity Reduced diarrhoea	The infant diarrhoea rate was low, suggesting benefits of regular medical care with hygiene package usage. Seventeen of 357 (4.8%, 95% CI 2.8–7.5%) of the infants and 3 (0.8%, 95% CI 0.2–2.4%) of the mothers were reported to have had at least one episode of diarrhoea
Ram K. Shrestha (Shrestha et al. 2006)	PLWHA HIV affected households	Unspecified age groups	Homebased care	Rural part of Uganda	196	Randomized controlled trial	To evaluate the cost and cost-effectiveness of safe water supply intervention for HIV affected households	Reduced morbidity Reduced diarrhoea	Safe water supply averted 37 diarrhea episodes and 310 diarrhea days and gained 0.155 DALYs for the entire household per 100 person-years of participation by HIV-affected households. No mortality benefit was reported
John R. Lule **Lule et al. 2005**	PLWHA HIV negative household members	Unspecified age group	Household	Rural part of Uganda	2030	Randomized controlled trial	To evaluate safe water intervention on the incidence and severity of diarrhea among persons living with HIV	Reduced morbidity Reduced diarrhoea	Safe water supply was equally effective with or without co-trimoxazole preventive therapy. Improved water supply interventions and co-trimoxazole prophylaxis together reduced diarrhea episodes by 67% (IRR _ 0.33, 95% CI _ 0.24–0.46, p < 0.0001), days with diarrhea (5.5 versus 10.5 days per person-years; IRR_0.46, 95% CI_0.32–0.66, p < 0.0001), and days of work or school lost due to diarrhea (2.9 versus 5.1 days per person-years; IRR _ 0.53, 95% CI _0.34–0.83, p _ 0.0056)

O Reilly et al. 2014	PLWHA and households	>18 years	Household	Amhara, Ethiopia	749	Randomized control trial	To evaluate effectiveness of preventive health interventions for PLWHA	Reduced morbidity Reduced diarrhoea	Intervention group clients were less likely than comparison clients to report illness from any cause (44% vs. 67%, $p < 0.05$) and fewer health facility visits for diarrhoea (4% vs. 7%, $p = 0.11$) than comparison clients.

Table 17: Mixed Method Appraisal Tool (MMAT) 1

Name of study author	Type of study	Methodological quality criteria	Y/N	Comments	Score
Prendergast et al, 2018 Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on stunting and anaemia among HIV-exposed children	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	N N Y Y Y	Inappropriate subject selection criteria with unclear research hypothesis	60%
Paletz et al. 2012 Assessing Water Filtration and Safe Storage in Households with Young Children of HIV-Positive Mothers: A Randomized, Controlled Trial in Zambia	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	Y Y Y N Y	A non-blinded design was used because previous attempts to blind the same intervention were unsuccessful; this can be a potential source of bias	80%
Barzilay et al. 2011 Diarrhea prevention in people living with HIV: an evaluation of point of use water quality intervention in Lagos, Nigeria	Quantitative Non randomized study	3.1. Are the participants representative of the target population? 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? 3.3. Are there complete outcome data? 3.4. Are the confounders accounted for in the design and analysis? 3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	Y Y Y N Y	Interpretation of a pre/post intervention study may be misleading, since changes in the outcome my be a reflection of the effect of the intervention or just a natural course of the the disease	80%
Xue et al. 2010 Use of nutritional and water hygiene packages for diarrhoeal prevention among HIV-exposed infants in Lilongwe, Malawi: an evaluation of a pilot prevention of mother-to-child transmission post-natal care service	Quantitative Non randomized study	3.1. Are the participants representative of the target population? 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? 3.3. Are there complete outcome data? 3.4. Are the confounders accounted for in the design and analysis? 3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	Y Y Y N Y	Women were enrolled at different times between October and March, and follow-up visits span into July, these months encompass both the dry and wet seasons, introducing more variability	80%
Shrestha et al. 2006 Cost-effectiveness of home-based chlorination and safe water storage in reducing diarrhea among HIV affected households in rural Uganda	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	Y Y Y Y Y		100%

Lule et al. 2005 Effect of home-based water chlorination and safe storage on diarhoea among persons with human immunodeficiency virus in Uganda	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	Y Y Y Y Y		100%
O Reilly et al. 2014 Improved health among people living with HIV/AIDS who received packages of proven preventive health interventions, Amhara, Ethiopia	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	N Y Y Y Y	Not clear	80%
Walson et al. 2013 Evaluation of impact of long-lasting insecticide-treated bed nets and point-of-use water filters on HIV-1 disease progression in Kenya	Randomized controlled trial	2.1. Is randomization appropriately performed? 2.2. Are the groups comparable at baseline? 2.3. Are there complete outcome data? 2.4. Are outcome assessors blinded to the intervention provided? 2.5 Did the participants adhere to the assigned intervention?	Y Y Y Y Y		100%

4.1.4. The effect of improved WaSH on linear growth

The study used a data extraction table shown in Table 16 to accumulate data that is useful to the systematic review question. The key outcome of the review was “LAZ -2 SD” at 59 months. Additional outcomes were “underweight” (weight-for-age) and “wasting” (weight-for-height), based on the WHO 2006 Child Growth Standard.

The effect of improved WaSH on linear growth

Table 18: Data Extraction Table 2

Author & year	Population				Sample size	Study design & methods	Objectives/aims		
	Participant	Age	Setting	Country			Study purpose	Outcomes	Results
Saaka et al. 2021	Children	6-23 months	Households	Ghana	301	Randomized controlled trial	To assess tHe effect of complementary feeding and poor WaSH practices on child growth	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Poor WaSH practices, were not associated with the risks of stunting. Poor complementary feeding practice was significantly associated with stunted growth.
Humphrey et al. 2019	Children from HIV negative mothers	0-18 months	Households	Zimbabwe	3686	Cluster Randomized controlled trial	To test the independent and combined effects of improved WaSH and improved IYCF on stunting	No effect of WaSH on linear growth as both treatment and experimental groups were the same	The IYCF intervention was more efficacious in increasing mean length-for-age Z scores among boys (0·24 [95% CI 0·14 to 0·34]) than among girls (0·07 [95% CI –0·04 to 0·17]).
Hill et al. 2020	Children	0-36 months	Households	South Africa	404	Randomized controlled trial	To determine whether the use of point-of-use water treatment technologies can improve child growth	No effect of WaSH on linear growth as both treatment and experimental groups were the same	The prevalence of diarrhea in the combined intervention group was 1.05 times (95% CI: 0.73, 1.50) the prevalence in the combined control group.
Walles et al. 2017	HEUI HUI	0-12 months	Households	Ethiopia	302	cross-sectional study	To determine the impact of exposure to maternal HIV infection in relation to socio-economic factors	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Unavailability of running water was associated with reduced risk for stunting (AOR 0.57; 95% CI 0.35–0.94; p = 0.026)
Null et al. 2018	Children	0-24 months	Household	Kenya	6659	Block Randomized controlled trial	To assess whether WaSH and nutrition interventions reduced diarrhoea or growth faltering	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Children in the combined WaSH and nutrition group were not significantly taller than children in the nutrition group (mean difference 0·04 [95% CI –0·11 to 0·19]

Sofeu et al. 2019	HEUI HIV + infants HEUI	0-59 months	Household	Cameroon	611	Randomized controlled trial	To determine the risk of HIV-related growth retardation during early childhood	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Although not statistical significant, the presence of water supply at home was a protective factor of stunting (aHR: 0.8, 95% CI: 0.6–1.0).
Prendergast et al. 2018	HEI and Children whose HIV status is unknown	≤18 months	Household	Zimbabwe	668	Cluster Randomized controlled trial	To evaluate the efficacy of WaSH and improved complementary feeding on child stunting	No effect of WaSH on linear growth as both treatment and experimental groups were the same	No difference in mean height for age Z-score (0.01, 95% CI-0.16 to 0.18) between WaSH and non-WaSH group. IYCF increased mean length for age Z score by 0·26 (95% CI 0·09–0·43; p = 0·003)
Christian et al. 2020	Children	6–23 months	Household	Malawi	2453	quasi-experimental study design	To perform an impact evaluation of the program using a neighboring district as comparison.	No effect of WaSH on linear growth as both treatment and experimental groups were the same	No differences in mean length-for-age z-score or prevalence of stunting were found at endline.
Fenn et al. 2012	Children	6-36 months	Household	Ethiopia	3758	Cluster Randomized controlled trial	To determine which interventions can reduce stunting in a food-insecure population in Ethiopia	WaSH significantly increased linear growth.	WaSH increased mean height-for-age Z-score (+0.33, P= 0.02), with a 12.1% decrease in the prevalence of stunting, compared with the baseline group.
George et al. 2020	children	6–36 months	Household	Bangladesh	2626	Cluster-randomized Controlled Trial	To determine the effect of a WaSH Mobile Health Program on Diarrhea and Child Growth in Bangladesh	WaSH significantly increased linear growth.	Children were less likely to be stunted in both the mHealth with 2 home visits arm (33% vs 45%; OR, 0.55 [95% CI: .31–.97]) and the mHealth with no home visits arm (32% vs 45%; OR, 0.54 [95% CI: .31–.96])

Deichsel et al. 2019	HIV-exposed infants	0-12 months	Household	Kenya	372	Longitudinal cohort study	To determine early life household, maternal, and infant factors associated with linear growth from birth to 12 months of life.	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Socio - economic status and sanitation were associated with change in LAZ. Infants in homes with pit latrines (p = .010), shared toilet (p = .032), or crowding (p = .005) experienced a greater deterioration of LAZ despite having similar LAZ at birth
Head et al. 2019	Children	0-59 months	Household	Ethiopia	1007	cross-sectional matched control evaluation	To compare the prevalence of stunting, wasting, underweight in children 0-59 month	No effect of WaSH on linear growth as both treatment and experimental groups were the same	Odds of stunting in the integrated group was 50% lower than children in the comparison group (OR: 0.50, 95% CI: 0.26, 0.97).
Bekele et al. 2020	Children	0-59 months	Household	Ethiopia	11023	observational study	To determine the effect of access to water, sanitation and handwashing facilities on child growth indicators	WaSH significantly increased linear growth.	WaSH group had 29% lower odds of linear growth failure (adjusted odds ratio (AOR) = 0.71; 95% CI: 0.51–0.99) compared with others.
Torlessee t al. 2016	Children	0-23 months	Household	Indonesia	1366	Cross sectional survey	To establish determinants of stunting in Indonesian children	WaSH significantly increased linear growth.	The prevalence of stunting and severe stunting was 28.4 % and 6.7 %, respectively. Odds on child stunting was over three times higher if the household used unimproved latrine

Table 19: Mixed Method Appraisal Tool (MMAT) 2

Name of study/ author	Type of study	Methodological quality criteria	Y/N	Comment	Score
Prendergast et al. 2018 Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on stunting and anaemia among HIV-exposed children in rural Zimbabwe	Cluster Randomized controlled trial	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y		100%
Humphrey et al. 2018 Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe	Cluster Randomized controlled trial	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y		100%
Null et al. 2018 Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya	Cluster Randomized controlled trial	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y		100%
Head et al. 2019 Integration of WaSH and nutrition programming is associated with lower prevalence of child and fever in Oromia, Ethiopia	Randomized controlled trial	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y		100%
Saaka et al. 2021 Independent and joint contribution of inappropriate complementary feeding and poor WaSH practices to stunte child growth	Quantitative Non randomized study	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y N Y N Y	Sample selection and design not clear The author has not come clear how to deal with confounders. For a cross-sectional study the cause effect relationship cannot be properly established because of the lack of a temporal sequence	60%
Christian et al. 2020 Impact Evaluation of a Comprehensive Nutrition Program for Reducing Stunting in Children Aged 6–23 Months in Rural Malawi	Quasi experimental study	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y		100%

Hill et al. 2020 Impact of Low-Cost Point-of-Use Water Treatment Technologies on Enteric Infections and Growth among Children in Limpopo, South Africa		2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y	100%
Walles et al. 2017 Growth pattern in Ethiopian infants – the impact of exposure to maternal HIV infection in relation to socio-economic factors	Quantitative non randomized (Cross sectional study)	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y Y Y Y Y	100%
Sofeu et al. 2019 Early treated HIV-infected children remain at risk of growth retardation during the first five years of life: Results from the ANRSPEDIACAM cohort in Cameroon	Quantitative non randomized (Cohort study)	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y Y Y Y Y	100%
Fenn et al. 2012 An evaluation of an operations research project to reduce childhood stunting in a food-insecure area in Ethiopia	Quantitative non randomized	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y Y Y Y Y	100%
George et al. 2020 Effects of a Water, Sanitation, and Hygiene Mobile Health Program on Diarrhea and Child Growth in Bangladesh	Block randomised controlled design	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y	100%

Deischel et al. 2019 Birth size and early pneumonia predict linear growth among HIV‐exposed uninfected infants	Quantitative non randomized (Cohort study)	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y Y Y Y Y	100%
Bekele et al. 2020 The effect of access to WaSH on child growth indicators: Evidence from the Ethiopia Demographic and Health Survey 2016	Quantitative non randomized (Cross sectional study)	3.1. Participants' representativeness 3.2. Appropriateness of measurements with regard to the outcome and intervention 3.3.Completeness of outcome data 3.4. Accounting for confounders in the design and analysis 3.5. During the study period, isAdministering of the intervention administered during the study period	Y Y Y Y Y	100%
Torlesse et al. 2016 Determinants of stunting in Indonesian children: evidence from a cross-sectional survey indicate a prominent role for WaSH sector in stunting reduction	Randomised controlled trial	2.1.Appropriate randomization? 2.2. Comparability of groups at baseline 2.3. Completeness of outcome data 2.4. Blinding of outcome assessors to the intervention 2.5 Participants adherence to the assigned intervention	Y Y Y Y Y	100%

4.1.5. The effect of helminth infections on HIV disease progression

The study used a data extraction table shown in table 17 to accumulate data that is useful to the systematic review question. We hypothesized that pre-existing helminths infestations may lead to impaired immune control of HIV-1, resulting in escalating HIV-1 viral loads and reduced levels of CD4+ T-lymphocyte count and higher likelihood of vertical HIV-1 transmission. All the studies involved HIV-1 infected persons who were recently treated for helminthiasis, or had a laboratory confirmed diagnosis of helminthiasis. The MMAT tool in table 18 was used to appraise the selected studies.

The effect of helminth infections on HIV disease progression

Table 20: Data Extraction Table 3

Author & year	Population				Sample size	Study design & methods	Study purpose/	Results	
	Participant	Age	Setting	Country			Objective	Outcome (VL and CD4+)	Results (VL and CD4+)
Kallestrup et al. 2005	Helminths and HIV-1 co-infected persons (130)	Adult	Hospital/ Facility-based	Zimbabwe	287	RCT	To determine the effect of helminths and their treatment on VL and CD4 count	Significant reduction in plasma HIV-1 RNA Significant rise in CD4+ count	Early treatment resulted to increase in CD4+ count ($p < 0.05$); Early treatment resulted to significant lower increase in plasma HIV-1 RNA ($p < 0.05$)
Wolday,et al. 2002	Helminths and HIV-1 co-infected persons (31)	Adult	Hospital/ Facility-based	Ethiopia	56	RCT	To study the effect of antihelminthic treatment on HIV plasma VL in HIV- and helminth-co-infected PLWHA	Significant reduction in plasma HIV-1 RNA No significant changes in CD4+ count	No significant changes in CD4 T-lymphocyte counts between baseline and the 6-month follow up for all groups. Successful treatment resulted to a mean decrease in HIV plasma log10 VL of −0.36 (±0.83) that was not correlated to CD4+ levels.
Walson et al. 2010	Helminths and HIV-1 co-infected persons (298)	Adult	Hospital/ Facility-based	Kenya	1541	RCT	To determine prevalence and correlates of helminth among HIV-1 infected adults	No changes in plasma HIV-1 RNA No significant changes in CD4+ count	Baseline median CD4+ counts were similar between those with infection at follow-up and those without (489 vs. 474, $p = 0.99$), as were baseline median log10 HIV RNA levels (5.1 log10 vs 4.9 log10 HIV RNA, $p = 0.29$).

Adeleke et al. 2015	Helminths and HIV-1 co-infected persons (57)	Adult	Hospital/ Facility-based	South Africa	252	Cross-sectional	To investigate the prevalence of intestinal helminth infestation among adults living with HIV	No changes in plasma HIV-1 RNA No significant changes in CD4+ count	No statistically significant differences in the mean CD4+ cell count (p = 0.79) in both groups. However, low CD4 count (< 200 cells/μL) was associated with intestinal helminth infection. This was statistically significant (p = 0.05)
Downs et al. 2017	Helminths and HIV-1 co-infected persons Helminths un-infected and HIV-1 un-infected persons Helminths infected and HIV-1 un-infected persons	Adult	Hospital/ Facility-based	Tanzania	3146	Case-control study	To determine whether schistosome infection affects susceptibility to HIV-1 acquisition and HIV-1 V/L at the time of seroconversion	Significant reduction in plasma HIV-1 RNA No significant changes in CD4+ count	Helminths at the time of HIV-1 infection led to a 0.7 log10 increase in V/L at sero-conversion. A sustained 0.7 log10 HIV-1 V/L increase equates with an approximate doubling in infectivity among co-infected individuals and would be expected to accelerate time to symptomatic AIDS
Walson et al. 2008	Helminths and HIV-1 co-infected persons (299)	Adults	Hospital/ Facility-based	Kenya	1,551	RCT	To determine effect of treatment on markers of HIV-1 disease progression	Significant reduction in plasma HIV-1 RNA No significant changes in CD4+ count	Mean plasma viral load was 4.75 log10 copies/mL at enrolment. Successful treatment resulted to a trend for 0.54 log10 lower HIV-1 RNA levels (p = 0.09).
Brown et al. 2001	Helminths and HIV-1 co-infected persons (299)	Adults	Hospital/ Facility-based	Uganda	663	Prospective cohort study	To assess the relationship between helminths and HIV	Significant reduction in plasma HIV-1 RNA No significant changes in CD4+ count	At the time of enrollment into the study, the mean viral load was 4.86 log10 copies/mL (SD, 0.88 log10 copies/mL). Persistence of infection at

							disease progression		follow-up was associated with a decrease in V/L (from 4.86 to 4.67 log10 copies/mL). p = .009.
Mulu et al. 2013	Helminths and HIV-1 co-infected persons (87)	Adults	Hospital/ Facility-based	Ethiopia	220	prospective observational study	To define the impact of helminth infection and treatment on V/L and T cell subsets in chronic HIV-1-infected patients	Significant reduction in plasma HIV-1 RNA No significant changes in CD4+ count	Follow up at 12 weeks after treatment, there was no significant effect on CD4+ cell counts. At baseline, plasma viral load was significantly higher in individuals with helminths than those without helminth infection (5.01 log10 vs. 3.41 log10, p < 0.001). 12 weeks after antihelminthic treatment, plasma HIV RNA levels were reduced in the successfully treated group (p < 0.001).
Webb etal. 2012	Helminths and HIV-1 co-infected pregnant women	Adults	Hospital/ Facility-based	Uganda	264	RCT	To investigate the effect of helminth infections and their treatment during pregnancy on V/L	Significant reduction in plasma HIV-1 RNA No data for CD4+ count	Helminths were associated with higher mean V/L at enrolment (adjusted mean difference 0.24log10 copies/ml, 95% confidence interval (CI): 0.01 to 0.47, p = 0.03 and 0.37log10 copies/ml, 95%CI: 0.00 to 0.74, p = 0.05, respectively).

Rabiu et al. 2021	Helminths and HIV-1 co-infected pregnant women	Adults	Hospital/ Facility-based	Nigeria	197	Cross-sectional survey	To assess the effect of malaria and helminths on CD4+ count, hematocrit values and viral load among HIV-infected pregnant women	No significant changes in plasma HIV-1 RNA No significant changes in CD4+ count	Those with co-infection of helminth and HIV had a lower CD4+ count but this was not significant relative to those with HIV only. The mean V/L and hematocrit values were not significantly different in the co-infection groups relative to those with HIV-infection only.

Table 21: Mixed Method Appraisal Tool (MMAT) 3

Name of study/ author	Type of study	Methodological quality criteria	Y/N	Comment	Score
Kallestrup et al. 2005 Schistosomiasis and HIV-1 Infection in Rural Zimbabwe: Effect of Treatment of Schistosomiasis on CD4 Cell Count and Plasma HIV-1 RNA Load	Randomized controlled trial	2.1. Randomization appropriate? 2.2. Group comparability at baseline 2.3. Completeness (outcome data) 2.4. Blinding of intervention 2.5 Adherence to the intervention	Y Y Y Y Y		100%
Wolday et al. 2002 Treatment of Intestinal Worms Is Associated With Decreased HIV Plasma Viral Load	Randomized controlled trial	2.1. Randomization appropriate? 2.2. Group comparability at baseline 2.3. Completeness (outcome data) 2.4. Blinding of intervention 2.5 Adherence to the intervention	Y Y Y Y Y		100%
Walson et al. 2010 Prevalence and Correlates of Helminth Co-infection in Kenyan HIV-1 Infected Adults	Randomized controlled trial	2.1. Randomization appropriate? 2.2. Group comparability at baseline 2.3. Completeness (outcome data) 2.4. Blinding of intervention 2.5 Adherence to the intervention	Y Y Y Y Y		100%
Adeleke et al. 2015 Intestinal helminth infections amongst HIV-infected adults in Mthatha General Hospital, South Africa	Cross-sectional	3.1. Sample representativeness 3.2. Measurements (outcome/intervention) 3.3. Completeness (outcome data) 3.4. Accounting for confounders 3.5. Timing of the intervention	Y Y Y Y Y		100%
Downs et al. 2017 Effects of schistosomiasis on susceptibility to HIV-1 infection and HIV-1 viral load at HIV-1 seroconversion: A nested case-control study	Case control	2.1. Randomization appropriate? 2.2. Group comparability at baseline 2.3. Completeness (outcome data) 2.4. Blinding of intervention 2.5 Adherence to the intervention	Y Y Y Y N		80%
Walson et al. 2008 Albendazole treatment of HIV-1 and helminth co-infection: A randomized, double blind, placebo-controlled trial	Randomized controlled trial	2.1. Randomization appropriate? 2.2. Group comparability at baseline 2.3. Completeness (outcome data) 2.4. Blinding of intervention 2.5 Adherence to the intervention	Y Y Y Y Y		100%

Brown et al. 2001	Prospective	3.1. Sample representativeness	Y	100%
Helminth Infection Is Not	cohort study	3.2. Measurements (outcome/intervention)	Y	
Associated with Faster Progression		3.3. Completeness (outcome data)	Y	
of HIV Disease in Coinfected Adults		3.4. Accounting for confounders	Y	
in Uganda		3.5. Timing of the intervention	Y	
Mulu et al. 2013	Prospective	3.1. Sample representativeness	Y	100%
Deworming of intestinal helminths	observational	3.2. Measurements (outcome/intervention)	Y	
reduces HIV-1 subtype C viremia in		3.3. Completeness (outcome data)	Y	
chronically co-infected individuals		3.4. Accounting for confounders	Y	
		3.5. Timing of the intervention	Y	
Webb et al. 2012	Randomized	2.1. Randomization appropriate?	Y	80%
The effect of anthelminthic treatment	controlled trial	2.2. Group comparability at baseline	Y	
during pregnancy on HIV plasma		2.3. Completeness (outcome data)	N	
viral load; results from a		2.4. Blinding of intervention	Y	
randomised, double blinded,		2.5 Adherence to the intervention	Y	
placebo-controlled trial in Uganda				
Rabiu et al. 2021	Cross-sectional	3.1. Sample representativeness	Y	100%
Malaria, Helminth Infections and		3.2. Measurements (outcome/intervention)	Y	
Clinical Status Among HIV-Infected		3.3. Completeness (outcome data)	Y	
Pregnant Women		3.4. Accounting for confounders	Y	
		3.5. Timing of the intervention	Y	

CHAPTER FIVE: DISCUSSION

5.1. Overview

In this study, we compared diarrhoea prevalence (recall period: 2 weeks) and risk factors among HEI under the age of 24 months in Malawi's central district of Kasungu. The primary outcome of the study was diarrhoea. Additional outcomes were linear growth trajectory and disease progression. All participants in this study were taking co-trimoxazole prophylaxis from the age of 6 weeks to 24 months (regardless of their adherence to standard protocol). Diarrhoea was determined as perceived by mother or caregiver, or as three or more loose or watery stools per day, or blood in stool. The question "*Has child had diarrhoea in the last two weeks, that is, since (day of the week) of the week before last*?" was posed to a mother or caregiver.

5.1.1. The effect of socio-demographic characteristics on diarrhoea among HEI

The study of the causal relationship between social-demographic characteristics and diarrhoea revealed several noteworthy findings. Firstly, when evaluating age groups, infants from mothers who were aged between 25-34 years had a slightly higher risk of diarrhoea than those aged 15-24 years, although this difference was not statistically significant. Infants whose mothers where aged 35 years and older had a lower risk of developing diarrhoea than the reference group (15-24 years old), with an adjusted odds ratio (AOR) of 0.79 (95% CI: 0.38-1.61). Regarding ethnicity, the findings revealed no significant variations in diarrhoea prevalence between the Chewa, Tumbuka, and Yao ethnic groups and a designated 'Other' category. Marital status exhibited significant relationships with diarrhoea prevalence. HEI whose mothers were married had considerably higher risk of suffering diarrhoea than single individuals (AOR: 3.64, 95% CI: 1.85-7.19), and widowed persons had an increased risk as well, though not statistically significant. Divorced people had a reduced risk of diarrhoea than

the reference group. Education level surfaced as a very powerful predictor of diarrhoea prevalence. Participants with secondary or tertiary education had significantly greater risks of diarrhoea than those without formal education, with AORs of 2.22 (95% CI: 1.18-4.20) and 9.72 (95% CI: 4.11-22.96), respectively. The chances were substantially higher for individuals with primary education (AOR: 9.39, 95% CI: 2.58-34.14). Employment status also had a strong relationship with diarrhoea prevalence. HEI whose mothers were self-employed, had a greater risk of acquiring diarrhoea than their counterparts whose mothers were from formal employment (AOR of 2.46 (95% CI: 1.22-4.93). Furthermore, the odds were significantly higher for the unemployed (AOR: 16.76, 95% CI: 2.19-128.41).

5.1.1. 2. Age Group

In our study, infants from mothers who were aged between 25-34 years had a slightly higher risk of diarrhoea than those aged 15-24 years, although this difference was not statistically significant. Infants whose mothers where aged 35 years and older had a lower risk of developing diarrhoea than the reference group (15-24 years old), suggesting that empowering younger women of child-bearing age with knowledge and support contributes to better childcare practices and healthier outcomes. The results further suggest that younger women (for instance primigravids) represent a crucial teaching opportunity and engagement during these care visits. Antenatal and postnatal care, birth preparedness, and informed decision-making can positively impact maternal and child health outcomes. Similarly, elderly mothers (35 years and older) are more likely to be honest with better health-seeking behaviour which can lead to more reported cases of HEI diarrhoea by this age group. Again, infants whose mothers where aged 35 years and older had a lower risk of developing diarrhoea than the reference group because they were more experienced and more likely to be at home and less mobile most of the time. There were likely to be focused in terms of childcare practices for their HEI than any other age-group.

5.1.1. 3. Marital Status

Historically, marital status is an established predictor of financial stability in most Low and Middle-Income Countries (LMIC), with continuously married people enjoying considerable economic benefits that accumulate earned by their spouses, contrasting sharply with the economic vulnerabilities faced by divorced, widowed, or single women who have not married before (Karraker and Dorius 2016). Marriage has generally been found to improve socio-economic status among women (Frech et al. 2017; Painter et al. 2015; Ruel and Hauser 2013; Ulker 2009; Vespa and Painter 2011) as a result of aggregation of outputs produced separately by each partner faster than they would as two single individuals (Becker 1981), and resource pooling. This is a demonstration that marriage reinforces the wealth-enhancing effect. Given that men are generally more financially literate than women (Lusardi and Mitchell 2008) and that women tend to be more risk averse than men (Croson and Gneezy 2009), married couples may allocate their wealth in a way that yields a higher return on compared with unmarried women (Bertocchi et al. 2011; Christiansen et al. 2015).

Marital status exhibited significant relationships with diarrhoea prevalence. HEI whose mothers were married had considerably higher risk of suffering diarrhoea than single individuals (AOR: 3.64, 95% CI: 1.85-7.19), and widowed persons had an increased risk as well, though not statistically significant. Divorced people had a reduced risk of diarrhoea than the reference group. Given that this study was conducted in poor resource settings where a significant proportion of diarrhoeal disease result from unsafe drinking water and inadequate WaSH. This result can be attributed to competing demands against meagre resources which compromise WaSH needs for families caring for PLWHA as well as HEI. Another possible reason could be that caregivers' responsibility are higher and family-centred as opposed to single women living alone who have more time and attention for their health and HEI. When

it comes to shared living spaces and the occurrence of childhood diarrhoea, there are some important considerations such as collective hygiene and adherence to preventive measures which are easier sustained by single mothers than married women who are likely to face adherence challenges. Our study further showed that HEI staying with widowed persons had an increased risk of acquiring diarrhoea, though not statistically significant. Divorced people had a reduced risk of diarrhoea than the reference group. As expected, the prevalence of Major Depressive Disorder (MDD) and anxiety disorders are considerably elevated in widowed individuals, during the first year of bereavement (Khristiansen et al. 2019). The impact of depression extends beyond just mood and emotions, as it can affect various aspects of daily life, including hygiene habits. People living with depression may struggle to maintain personal hygiene and that of their HEI.

5.1.1. 4. Education Level

The positive association between education and health is well established. According to Zimmerman and Woolf (2014), education enables people to secure employment and earn high income. Empirically, hundreds of studies have documented how education is linked to improved health outcomes and how the lack of it worsens general health (Mirowsky & Ross 2008; Zajacova and Hummer 2012), more chronic conditions (Lawrence 2017; Quiñones et al. 2016), and more functional limitations and disability (Zajacova and Montez 2017; Tsai 2016). Participants whose mothers had secondary or tertiary education had significantly greater risks of diarrhoea than those without formal education, with AORs of 2.22 (95% CI: 1.18-4.20) and 9.72 (95% CI: 4.11-22.96), respectively. The chances were substantially higher for individuals with primary education. Interestingly, further analysis of our results revealed that HEI whose mothers had secondary or tertiary education had significantly greater risks of diarrhoea than those without formal education. Most of the research on the correlation between the levels of educational attainment and child diarrhoea prevalence rates has not

focused on establishing a causal link between the two (Sumampouw et al. 2019; Sinmegn et al. 2014). Instead, there has been more examination of the influence of a formal education (both primary and secondary) on child diarrhoea or hygiene and sanitation behaviour. Our study findings seem to suggest that there is a shift in the quantitative evidence surrounding education and child diarrhoeal prevalence. Examining the effect that years of educational attainment have on childcare practices is therefore key to understanding the complex relationship between levels of educational attainment and child diarrhoea prevalence rates. Our finding challenges the common assumption that high maternal education directly impacts child diarrhoea particularly in the context of HIV where stigma and negative stereotypes can be significant confounding factors. In summary, while education level alone does not directly cause diarrhoea risk, it intersects with various factors affecting maternal health, childcare, and disease prevention. Holistic support, including education and accurate information, healthcare, cultural norms and nutrition are all crucial for reducing diarrhoea-related risks among HEI.

5.1.1. 5. Employment Status

Lack of formal or informal employment pushes people into poverty and vulnerability to adverse health outcomes because they have less resources to reduce risks and they have lower ability to cope with and recover from their situation impact. Our study shows that mothers' employment status was a significant predictor of HEI diarrhoea. Employment status had a strong relationship with diarrhoea prevalence. HEI whose mothers were self-employed, had a greater risk of acquiring diarrhoea than their counterparts whose mothers were from formal employment (AOR: 2.46 (95% CI: 1.22-4.93). The odds were significantly higher for infants whose mothers were unemployed (AOR: 16.76, 95% CI: 2.19-128.41). Informal employment, which refers to work that falls outside the protection of national labour legislation, income

taxation, and social benefits, can have significant implications for health resulting from lower wages compared to formal employment. This financial strain can lead to stress, anxiety, and difficulties accessing quality healthcare services including that of their children due to low-income earnings. This has potential to delay seeking care and may lead to poor maternal and child health outcomes. As for the unemployed mothers, who had significantly higher odds for child diarrhoea, the lack of social protection may have likely led to their exclusion from social safety nets. Without access to unemployment benefits or other forms of social support, mothers living with HIV and their HEI face greater vulnerability during crises. This is so because women's expanded economic opportunity leads to better investment in child heath owing to enhanced financial accessibility to health inputs like nutritious diets, preventive health services and better access to services.

In our study, all participants had their likelihood of poverty index calculated to ascertain their diversity and poverty status. As such, we conveyed a better understanding of their socioeconomic status. The poverty status of every HEI represented an average of 41% likelihood of living below the extreme poverty line of $1.90 per day. In a way, this may have impacted on meeting their basic needs including proper WaSH. These results further highlight the inter-relatedness between employment status and diarrhoeal diseases which are prominent among HEI and PLWHA- a finding that is quite consistent with other empirical studies (Sumampouw et al. 2019; Ramlagan et al. 2018; Tamasane and Head 2010). The "Global strategy on Water, Sanitation and Hygiene to combat Neglected Tropical diseases (NTD) - 2021-2030" aligns with the Sustainable Development Goal targets 6.1 and 6.2 on drinking water and sanitation. NTDs such as worm infestations generally afflict the world's poorest households living in remote rural areas and urban slums (WHO, 2011). They are a sub-group of WaSH-related diseases and can be effectively controlled, eliminated or eradicated through a combination of effective WaSH interventions. Consistent with some

prior literature (as discussed above), we find that our study generates further evidence to advocate formalized employment among mothers living with HIV as it may be an effective method for mitigation of diarrhoea and other WaSH-related diseases among HEI.

5.1.2. The influence of WaSH descriptors on diarrhoea

The outcome variable of this study was the prevalence of diarrhea among children aged 0 – 24 months within the past 2 weeks preceding the survey. The interviewed women were asked whether their children who were under the age of 24 months had diarrhoea in the last 2 weeks. Explanatory (independent) variables included the following:

I. Toilet Location
II. Toilet Category
III. Fixed H/W & Soap availability
IV. Sanitary condition of a latrine
V. Access to drinking water supply

Based on the JMP service ladder, a toilet located inside of the house was considered to offer Good level of service. A toilet within the compound was categorized as Intermediate level of service, while that in the neighbour's compound or in a public place was described as Poor level of service. Not using a toilet at all was categorized as No level of service. The type of toilet facility based on the JMP sanitation ladder was regarded as Improved (Good level of service), Shared (Intermediate level of service), Unimproved (poor level of service) or Open Defecation (No level of service). The user safety and security while accessing the sanitation facility was assessed using the following parameters: Safe and secure (the physical integrity of users while accessing the facility was guaranteed) (Good level of service); Partially secure (Intermediate level of service); or Unsecure if the physical integrity of users while accessing the facility was not guaranteed (poor level of service). The accessibility of toilet facility for its continuity of use was described in the following manner: Full access (all day and night)

(Good level of service); Partial access (if the facility was available at least 18 hours per day) (Intermediate level of service). A toilet facility was considered to offer Limited access if it was available less than 18 hours per day (Poor level of service).

The sanitary condition of the latrine was assessed, described, quantified, and categorized as follows: *Adequate sanitary conditions* (no insects, no smell, adequately clean) **(Good level of service);** *Acceptable sanitary conditions* (few insects, slight unpleasant smell, some dirt but no faeces or urine) (**Intermediate level of service)** or *Poor sanitary conditions* (insects, strong unpleasant smell, faeces or urine on the floor) **(Poor level of service).** The general latrine standards were assessed, described, quantified, and categorized as *Adequate latrine standards* (lined pit, undamaged superstructure) **(Good level of service);** *Acceptable latrine standards* (inadequate lining of the pit and damaged superstructure) (**Intermediate level of service)** or *Poor latrine standards* (no lined pit, no superstructure) **(poor level of service).** As for handwashing, the following parameters were considered: *Hand-washing facility with water and soap / ash* **(Good level of service)**; *Hand-washing facility with no soap / ash* (**Intermediate level of service)** or *Hand-washing facility with no water / No hand-washing facility* **(poor level of service).** In terms of management and disposal of human excreta, parameters were defined as follows: *Safe disposal of excreta* (disposed in situ or treated off - site) **(Good level of service)**; *Safe removal / transport of excreta off-site, with no treatment* (**Intermediate level of service)**; *Unsafe emptying of pits / unsafe transport of excreta off-site / inadequate containment of faeces and urine* **(poor level of service).** Finally, the level of hygiene practices in the latrine were categorized as *Adequate hygienic practices* (availability of water and cleansing materials, adequate menstrual hygiene management, hygienic disposal of cleansing and menstrual products) **(Good level of service)**; *Acceptable hygienic practices* (**Intermediate level of service)** or Poor hygienic practices (no water / cleansing materials, inadequate menstrual hygiene management, unhygienic disposal of

cleansing and menstrual products **(poor level of service).** Drinking water from an improved water source that is accessible on premises, available when needed and free from faecal and chemical contamination was categorized as **Safely managed.** Drinking water from an improved source, and if collection time was not more than 30 minutes for a roundtrip including queuing was classified as **Basic service level.** Drinking water from an improved source for which collection time exceeded 30 minutes for a roundtrip including queuing was categorized as **Limited-service level;** while drinking water from an unprotected dug well or unprotected spring, river or irrigation canal was considered **Unimproved service level.**

Under this objective, the study findings revealed that households with limited-service level access had significantly greater chances of diarrhoea prevalence than those with safely managed access (AOR: 8.78, 95% CI: 4.58-16.83). Similarly, households with basic service level access had higher risks of diarrhoea than those with properly managed access (AOR: 7.56, 95% CI: 3.30-17.33). These findings show the importance of safe and consistent drinking water availability in lowering the incidence of diarrheal diseases, emphasizing the need for enhanced water infrastructure and quality assurance procedures. In terms of family sanitation status, households whose sanitation had deteriorated had considerably greater odds of diarrheal prevalence than those where sanitation had remained relatively stable (AOR: 6.17, 95% CI: 2.60-14.64). This underlines the significance of maintaining and enhancing sanitation facilities to prevent the spread of diarrheal infections within the home. In contrast, homes with considerably improved sanitation did not show a significant difference in diarrhoea prevalence compared to those with the same sanitation status, indicating that even little improvements in sanitation infrastructure can have major health advantages. In terms of hygiene, households with poor levels of service had significantly greater chances of diarrhoea prevalence than those with good levels of service (AOR: 12.64, 95% confidence interval: 6.24-25.61). Similarly, households with intermediate levels of

service had higher chances of diarrhoea than those with strong levels of service (AOR: 7.31, 95% CI: 3.61-14.82). These findings emphasize the crucial relevance of promoting and maintaining good hygiene standards in homes to avoid diarrheal diseases, as well as the need for comprehensive hygiene education and behaviour modification programs. In our study, however, toilets in own yard or in the neighbourhood did not significantly influence the occurrence of diarrhoea. This is so because the sample size used in this study may have been comparatively lower than large trials that UNICEF or WHO may employ on a similar study topic. Data for this study was collected during dry season when obvious barriers (such as rainfall, bad weather condition) to the use of toilets not located within the yard did not affect accessibility of the facility. However, we are quick to pre-warn that the location of toilet facility on premises is necessary to avoid temptations to devastating consequences of open defecation practice such as faecal contamination of the environment that can lead to child mortality, morbidity, under-nutrition and stunting (Chavura et al. 2022).

Generally, filthy or unsanitary latrines, signal the beginning point for descending the sanitation service ladder (Kwiringira et al. 2014). However, a cross-sectional study conducted in Western Ethiopia (Bekele et al. 2021) established that cleanliness of a latrine, among other variables were not found to be predictors of childhood diarrhoea. Similarly, data from our study indicates that use of latrines regardless of their cleanliness and aesthetic quality was still protective against diarrhoea among HEI. This finding is consistent with previous published studies that focused on latrine use as opposed to latrine ownership and suggests that the former is a more salient measure when examining the association between latrines and diarrhoea (Montgomery et al. 2010). Again, this is consistent with other studies that have reported health benefits from sub-optimal quality latrines (Odagiri et al. 2017). In their study, Cha et al. (2017) reported a diarrhoea risk reduction among children whose households used suboptimal quality latrines. This suggests that the latrine itself provides

health benefits, even if the sanitary condition of the facility is poor.

Our findings, however, are in sharp contrast with Semba et al. (2011) who reported that lack of an improved latrine, (among other variables) were significantly associated with child diarrhoea among rural families. We are quick to argue, however, that their characterization of latrine quality was ambiguous as it was neither aligned to the JMP standard classification nor based on the HHRR Normative Criteria. Improved sanitation facilities are designed to hygienically separate excreta from human contact to meet the criteria for having a safely managed sanitation service (SDG 6.2). Such a service is not shared with other households, and the excreta produced should either be treated and disposed of in situ, stored temporarily and then emptied and treated off-site, or transported through a sewer with wastewater and then treated off-site. These characteristics were largely missing in their research which may have led to the differences between our findings and that of other researchers such as Semba et al, (2011). Moreover, the same study (Semba et al. 2011) purposively sampled "very poor" participants i.e. "those in which the housing location was along train tracks, rivers/gutters/swamps, underneath toll road/ highways, near "waste station/dump areas," around small alleys, and/or near the beach; and where housing conditions included "box house" composed of cardboard, galvanized tin, plywood, bamboo, house with soil/uncemented floor, house attached to other houses, and house with wood floors". Such participants were likely to share similar characteristics such as living below the poverty line, inadequate water supply and poor sanitation, poor drainage and garbage collection and living in dense settlements; all of which can increase the prevalence of various diseases, including diarrhoea. The risk of diarrhoea among HEI has increased in the following circumstances: death of mother (Thea et al. 1993), early weaning (Harris et al. 2019; Fawzy et al. 2011; Xue et al. 2010), mother having diarrhoea and contaminated drinking water (Saaka et al. 2021; Peletz et al. 2011). In this study, we observed that latrines still offer health benefits regardless

of whether they are improved. Type of latrine and their sanitary quality had no significant influence ($p > 0.05$). We did not see a significant risk of diarrhoea amongst HEI in relation to unsanitary latrines, suggesting that the quality of latrines cannot be the sole explanation for diarrhoea, as other environmental pathways could not be fully exhausted. Another possible explanation as to why the quality of latrine did not contribute to diarrhoea could be that the study participants themselves who were aged between 0-24 months where not trained in utilizing the latrines. Rather they were simply used by caregivers for disposal of child excreta. Handwashing with soap is a cost-effective way of reducing diarrheal disease mortality in children under five and has been estimated to reduce the risk of diarrhoea by 23%–48% (Fewtrell et al. 2005; Cairncross et al. 2010; Freeman et al. 2014), and hygiene promotion is recognized as a cost-effective public health intervention to avert WaSH-related disease burden (Bartram and Cairncross 2010). However, tracking this practice among mothers and child caregivers is cumbersome, costly, and conducive to exaggerated performance (Shelus & Hernandez 2015). The proportion of the global population who practice handwashing with soap is very low. The estimated prevalence of handwashing with soap after using the toilet or contacting excreta is 19% globally, and it is lowest in sub-Saharan Africa at 14% (Freeman et al. 2014). A fixed place for washing hands after using the latrine has been traditionally known to be a handwashing proxy measure. We aimed to identify the influence of having a fixed handwashing station and soap in the vicinity of the latrine (together with other sanitation descriptors) on the occurrence of diarrhoea and other WaSH-related diseases. In this study, we consider this proxy measure as not an important factor i.e. having a designated place for handwashing was not protective against diarrhoea. Similarly, evidence from Multiple Indicators Cluster Survey and the Demographic Health Survey (DHS) from five countries namely Ethiopia, Ghana, Malawi, Sierra Leone, and Zimbabwe show that the

relationship is moderate in Malawi and less strong in Sierra Leone and Zimbabwe. No relationship was found in Ethiopia and Ghana (Shelus and Hernandez 2015).

Only drinking water source was a significant influencing factor of WaSH- related disease prevalence. Drinking water from an unimproved water source (i.e unprotected dug well or unprotected spring, river or irrigation canal) had a positive correlation with the occurrence of WaSH-related diseases at 5% significance level. The results of a study by Omotayo et al. (2021) show that households with access to clean water, and to water within their residence are less likely to record incidence of diarrhoea among under-five children.

Having access to drinking water from unimproved sources is linked to the prevalence of childhood diarrhoea (Rajal et al. 2010), however, the association is considered indecisive in the contemporary literature (Komarulzaman et al. 2017; Kamal et al. 2015; Hasan & Richardson 2017). Using a logistic regression model on several WaSH descriptors namely: toilet location, toilet Category, fixed H/W and soap availability, sanitary condition of a latrine, and access to drinking water supply, we observed that drinking water from an unimproved water source (i.e. unprotected dug well or unprotected spring, river or irrigation canal) had a positive correlation with the occurrence of WaSH-related diseases at 5% significance level. Limited access to potable water is a human rights violation (Solon 2010; The Human Right to Water 2015). Hence, inequity in the achievement of this commodity for poor and vulnerable groups within societies is a step towards failure to attain Sustainable Development Goal (SDG) target 6.1 (Hutton and Chase 2016) which highlights the need for access to safe and affordable drinking water for all by 2030. These targets are meant to achieve universal and equitable access to safe and affordable drinking water, sanitation, and hygiene for all and end open defecation (WHO 2021). The WHO/UNICEF Joint Monitoring Program (JMP) established the service ladders to show the wider range of services households receive rather than a binary improved/unimproved indicator. The levels are important indicators in getting

people in the higher rungs of the ladder since moving up the ladder reduces the risk of diarrhea (Mather et al. 2020; Bain et al. 2018).

5.1.3. The effect of improved WaSH practices on diarrhoea among HEI who take co-trimoxazole prophylaxis

The Relationship Between Adherence to NVP, CPT and Diarrhoea

The relationship between adherence to NVP, Co-trimoxazole prophylaxis and diarrhoea prevalence in children generated interesting results. In terms of adherence to Nevirapine prophylaxis, children with good adherence had significantly greater odds of diarrhoea than those with poor adherence (AOR: 6.87, 95% CI: 1.30-36.24), whereas the odds were not statistically different for those with uncertain adherence. Similarly, adherence to Co-trimoxazole prophylaxis did not significantly correlate with diarrhoea prevalence suggesting that co-trimoxazole alone, though a proven intervention for the control and prevention of diarrhoea and other OIs among HEI, may have been insufficient to overcome diarrhoea which results from constant exposure to the poor environment and WaSH practices, which in this study were found to be dominant. Another explanation to these results could be that the study was not a randomized controlled trial which can ably measure the effectiveness of an intervention or treatment. Although no study is likely on its own to prove causality, randomization reduces bias and provides a rigorous tool to examine cause-effect relationships between an intervention and the outcome. This is because the act of randomization balances participant characteristics (both observed and unobserved) between the groups allowing attribution of any differences in outcome to the study intervention. This is not possible with any other study design.

Empirical evidence from the eight studies that we included in the systematic review to resolve this research question, reported diarrhoea as an outcome. The studies suggest that safe water has added protective effects against morbidity for persons who take prophylactic antibiotics for opportunistic infections. Notably, one study (Xue et al. 2010) observed that point-of use water treatment and hygiene education were associated with lowered diarrheal

rates in HEI before and after weaning. This is a positive assertion of the complementarity of safe water (a non-biomedical intervention) and other existing biomedical interventions for HEI. A study in Zambia (Peletz et al. 2012), found that water filtration and safe water storage led to significant reductions in the longitudinal prevalence of diarrhea among HEI and their family members too. This extended benefit provides convenient home-based care practices and minimizes person to person transmission of diarrhea-causing pathogens within HIV affected family members.

Despite this evidence, results from other studies (Prendergast et al. 2018; O'Reilly et al. 2014; Wilson et al. 2013; Barzilay et al. 2010; Shrestha 2006; Lule et al. 2005) focused on co-trimoxazole typically for PLWHA in general. Reduction in HIV disease progression was reported in only one prospective observational study (Wilson et al. 2013) of combined effects of long lasting insecticide treated bed nets and point-of-use water filtration. The combined intervention resulted in risk reduction in HIV disease progression.

Interestingly, the safe water intervention study in Zimbabwe on HEI (Prendergast et al. 2019) did not establish a consistent effect on diarrhoea. It was hypothesized that safe water and WaSH in general would reduce diarrhoea and prevent enteric dysfunction which would in turn, reduce stunting. Although uptake of the WaSH intervention was considered high, the intervention intensity might have been too low to modify household behaviours to the extent necessary to affect desired health outcomes. Secondly, the study had complexities in the initial enrolment of research participants as they ranged from HEI, HIV-exposed uninfected (HEU) and HIV-unexposed (HU) infants and those that had uncertain HIV status. Other research participants included pregnant and breastfeeding mothers. Since the sample size for the trial was based on detecting a difference in length for age *z*- score among HU infant group, the researcher did not calculate a specific sample size for HEI. It is highly likely that the null effect of the WaSH intervention was due to insufficient power to detect an effect. Again, we

reasoned that group sizes were vastly unequal with violation of homogeneity of variance then a possible underestimation of the significance level would ensue resulting in false rejection of the null hypothesis.

In this study, we hypothesized that the combined effect of co-trimoxazole prophylaxis and WaSH practices on diarrhoea was not significantly different than when each one of them were to be offered alone. Our study findings show that WaSH interventions and co-trimoxazole prophylaxis together reduced diarrhea episodes by up to 67% (IRR _ 0.33, 95% CI 0.24–0.46, $p < 0.0001$). The combined interventions resulted in 27% risk reduction in HIV disease progression whilst safe water alone was associated with reductions in the longitudinal prevalence of reported diarrhea of up to 53% among HIV exposed infants aged ≤2 years (LPR = 0.47, 95% CI: 0.30–0.73, $p < 0.001$). We therefore, reject the null hypothesis as the combined effectiveness of the two approaches was more efficacious that their individual contribution.

5.1.4. The effect of improved WaSH on linear growth

There is discordant evidence on the effect of WaSH on linear growth. While other studies suggest that linear growth is significantly linked to poor sanitation, some have reported no association. In this systematic review we collated the current state of knowledge and the uncertainty about inconsistent outcomes. We critically appraised, summarized and attempted to reconcile the published evidence on the effect of improved sanitation on stunting. All the included studies reported linear growth as a primary outcome, and must have been explicitly defined within the manuscript or abstract. We reviewed evidence on the effect of WaSH interventions on nutritional outcomes. We also reviewed studies that reported integrated WaSH and nutrition as long as the design and methodology was able to clearly separate and allow individual evaluation of the combined interventions.

While improved sanitation interventions are critical in eliminating microbes from the child's surrounding, intervention studies were usually time-bound, hence subject to poor compliance and limited exposure making it unlikely to stimulate linear growth. Regardless of child's HIV status, WaSH interventions provided no special benefit to improve linear growth in settings with high prevalence of stunting and poor sanitary conditions. Arguably, fecal–oral transmission of these pathogens might have occurred through other environmental pathways which may not have been fully addressed by elementary WaSH interventions. This study observed no difference in mean height for age z-score (0.01, 95% CI-0.16 to 0.18) between children who received WaSH interventions and those who did not. Only 5 studies reported significant association between WaSH and child linear growth ($p < 0.001$). All combination intervention studies included in this review did not establish any significant benefit of WaSH and nutrition integration. While protective, combined-treatment groups produced statistically significant but inconsistent, outcomes. Consistent with the available evidence, neither intervention on its own may be sufficient to measurably improve linear growth without firm logical contradictions. Contextual factors, or study settings and population characterstics may have contributed not to find effect as others may have done. It is also worthy noting that different disciplines have different error tolerance thresholds, hence variation of results from similar studies conducted by different researchers. There was obvious bias towards funding authority in some isolated studies and consequent failure to limit the same, leading to under-reporting or overemphasizing the reporting of some outcomes, All this can still lead to differences between findings of our current study and other researchers'.

As we are unable to rule out residual correlations between unobservable household characteristics and our primary outcome; we might underestimate the effects of improved water supply and sanitation. However, as we earlier hypothesized, linear growth failure is multifaceted, and observance to WaSH practices alone may not reduce the odds of stunting.

Although a robust sanitation coverage could be an important component among proven interventions to stimulate linear growth, stunted growth is embedded within a myriad determinants beyond improved WaSH alone. More research is needed to quantify the complementary effect of WaSH and nutrition co-programming.

5.1.5. The effect of helminth infections on HIV disease progression among helminth/HIV-1 co-infected persons

Mixed opinions on the effect of helminths infections on HIV disease progression among PLWHA are not new. They emanate from contextual factors, or study settings, sampling framework, methodological limitations, characteristics of the study population, and in some cases failure to limit bias on the part of researchers and variations in error tolerance thresholds. To resolve the research question, we critically appraised and summarized the published evidence on the effect of helminth infections on HIV disease progression among PLWHA. Our study outcomes were plasma HIV-1 RNA V/L and Cluster of CD4+ T-lymphocyte count among helminth-HIV-1 co-infected persons. We also evaluated the efficacy of specific treatment on these prognostic markers.

Early treatment resulted in significantly higher CD4+ counts among individuals with Ascaris lumbricoides infestation (Walson et al. 2008) and lower VL. (Downs et al. 2017; Adeleke et al. 2015; Webb et al. 2012; Kallestrup et al. 2005). Specifically, a 1·0 $\log_{10}$ copies per mL drop in plasma viral load translate to a 2-year delay in the development of an AIDS-defining condition. The same amount of plasma HIV-1 RNA decline takes away half of HIV-1 transmission risk. Our analysis showed a V/L decline of at least 0·6 $\log_{10}$ copies per mL from the included studies. This evidence supports that even small declines can lead to the slowing down of HIV progression and could positively contribute towards lowering HIV transmission risk amongst the larger population (Modjarrad et al. 2010). Treatment of co-infections prevalent among PLWHA might therefore result in suppression of plasma HIV-1 RNA

concentrations, delay time to an AIDS-defining event and substantial public-health risk reduction.

No statistically significant difference was seen between the co-infection groups relative to those with HIV-infection alone. The lack of association between CD4 count and intestinal helminth infection in the present study could be attributable to the small sample sizes that were used in the primary studies (see study characteristics) and the ultimate number of studies that made it to the final selection for this systematic review, some of which were not designed specifically to address this hypothesis. Declining CD4+ counts have been closely linked with higher burdens and severe forms of strongyloidiasis, ascaris and hookworms infestation (Bava et al. 2009). Significant decline in the prevalence of helminths have been reported among persons who are adherent to antiretroviral therapy (ART), suggesting that immune recovery may result in protection against some forms of helminth infestation (Tran et al. 2019; Walson et al. 2010; Bava et al. 2009; Bachur et al. 2008). This can well be extended to the reason of a lack of mortality in helminths–infested subjects in the current study suggesting that CD4+ cells mirror a real immune advantage in HIV-infected subjects.

The lack of association between helminth infestation status and lower CD4+ cell count argues against the second part of our hypothesis and sharply contradicts the results of other previous studies (Brown et al. 2021; Adeleke et al. 2015; Borkow et al. 2000). We hypothesized that concurrent helminths infestations may lead to impaired immune control of HIV-1, resulting in escalating HIV-1 V/L and reduced levels of CD4+ T-lymphocyte count. Subject to successful treatment, we hypothesized a decrease in plasma HIV-1 RNA load and slowing down of HIV-1 disease progression. In this study, we have demonstrated that helminths are associated with an increase in HIV-1 RNA levels that tend to spur progression of sub-clinical disease to symptomatic AIDS. In the same way, successful treatment of intestinal helminths reduced plasma viral load among co-infected persons. There were inconsistent results on the

effect of helminths on CD4+ T-lymphocyte count as values were not significantly different in the co-infection groups relative to those with HIV-infection alone. Plasma human immunodeficiency virus type 1 (HIV-1) V/L and CD4+ cell count are used to predict the likely outcome or course of disease among persons infected with HIV.

5.2. Study Limitations

Citing and referencing prior research studies constitutes the basis of the literature review for the study, and these prior studies provide a better theoretical foundation for the research question under investigation. However, due the scope of the research topic, there was limited prior research on the topic of study particularly from Malawi from which this study took place. We therefore present these limitations as an important opportunity to identify literature gaps and to present the need for further development in this area of study. Primary data were collected at one point in time (cross sectional), this methodological deficiency might have impacted on addressing fully all research questions. As such, other important questions in the survey had to be left out. Future researchers may need to revise their specific methods for collecting data that includes this shortcoming. As an academic study, the research was subject to strict deadlines and therefore the initially proposed longitudinal research design had to be modified accordingly. The time available to study a research problem and to measure change over time might have been constrained by such practical issues.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Poor WaSH dis-proportionally affects the most vulnerable groups in society such as HEI and PLWHA. The research evaluated the effectiveness of WaSH in reducing morbidity and mortality among infants exposed to HIV/AIDS. The results of this study show that socio-demographic factors, level of education and employment status have significant influence on diarrhoea among HEI. This study, therefore, rejects the hypothesis because according to the findings, demographic characteristics have significant effect on the incidence of diarrhoea in Kasungu, Malawi. The study hypothesized that WaSH descriptors have no significant influence on the prevalence of diarrhoea among HEI. Accordingly, this hypothesis is rejected based on the study findings as many WaSH descriptors were observed to have significant influence on child diarrhoea. The added effect of co-trimoxazole and safe water was significantly higher than when each one of them were to be offered alone. The combined interventions resulted in risk reduction in HIV disease progression whilst safe water alone was associated with reduction in the longitudinal prevalence of reported diarrhoea. The study hypothesis is therefore rejected, as combined efforts carried more impact. According to this study findings, helminths and HIV-1 co-infections were associated with an increase in HIV-1 RNA levels that accelerate the progression of the sub-clinical disease to symptomatic AIDS. However, CD4+ T-lymphocyte count values were not significantly different in the co-infection groups relative to those with HIV-infection alone. In the research hypothesis, it was stated that helminth infections have no significant effect on HIV disease progression among helminth-HIV-1 co-infected persons. Again, this hypothesis is rejected as helminth infections significantly compromised immune control, resulting in rising VL. It was further hypothesized that improved WaSH has no significant effect on linear growth. In this study, no difference was seen in mean height for age z-score between children who received WaSH

interventions and those who did not implying that much as a robust sanitation coverage could be an important component among proven interventions to stimulate linear growth, stunted growth is embedded within myriad determinants beyond improved WaSH. We therefore accept this hypothesis as WaSH has no effect on child linear growth.

In conclusion, poor WaSH dis-proportionally affects the most vulnerable groups in society such as HEI. The study evaluated the potential contribution of WaSH and helminths control towards three outcomes: diarrhoea prevention, linear growth trajectory and disease progression among helminths/HIV-1 co-infected infants and PLWHA. Based on the findings of this study, besides the on-going recommended use of cotrimoxazole prophylaxis, improved WaSH among HEI could be a cost-effective and sustainable intervention for the prevention of diarrhoea and remedy for slowing down the progression of the sub-clinical disease to symptomatic AIDS; but has inconsistent effects on linear growth trajectory. Given the dreadful state of living conditions among most HEI, biomedical interventions alone though necessary, are insufficient and narrow in scope. An expanded WaSH/HIV response to address exposed infants' vulnerability, therefore, offers them a more pragmatic recourse!

5.2. Recommendations

a. The level of education, employment status and marital status were significant predictors of diarrhoea. This study therefore recommends the following:
    i. Empowering mothers/caregivers of HEI with effective WaSH education programs and
    ii. increasing female school enrolment, as these would reduce WaSH-related morbidity among HEI in the study area.

b. Introduction of social protection schemes for mothers/caregivers of HEI who are not formally employed to reduce income inequalities and social exclusion, both of which are potentially risk factors for the further spread of HIV. The social protection scheme could also make it easier for people to access HIV and other health services, and can cushion the social and economic impact of HIV on households and individuals who are not in the formal or informal employment. Social protection is a proven strategy in LMICs to increase adherence to HIV treatment and scheduled appointments while fostering resilience.

c. The study recommends that all households caring for HEI must be encouraged at minimum, to own a low-cost latrine. Low-cost latrines are an option to achieving open defecation-free communities and sanitation for all (SDG 6) because they may be attained more quickly and inexpensively, even among limited resource households.

d. This study proposes an expanded WaSH response in fighting HIV among infants to curb multiple opportunistic infections through the following key strategic ways:

    i. Co-programming: WaSH sector should carry out a gap analysis and mainstream HIV/AIDS into their work. Similarly, The HIV/AIDS sector should carry out a gap analysis, and mainstream WaSH.

    ii. Develop common WaSH/HIV indicators and collect baseline data on the WaSH needs for PLWHA to increase knowledge and understanding of WaSH/HIV situation

    iii. Social prescribing (community referral) to a range of local, non-clinical services from healthcare professionals working in primary care settings to address people's needs in a holistic way and to support individuals to take greater control of their own health.

iv. Introduction of Differentiated Service Delivery (DSD) Model ie. Restructure patient follow-up schedule (Introduce DSD Model of care for HEI) and integrate "well-child" visits with IMCI village clinics to reduce travel costs and to combat sub-optimal long-term retention in HIV care. Collect WaSH/HIV anthropometric data through HSAs and HSAs should submit WaSH reports for HEI.

v. Introduce Basic care packages (BCPs) for HEI in the form of water treatment, chemical agents, water vessel, water filters, anti-bacterial soap and oral rehydration salt (ORS).

e. This study also evaluated the efficacy of WaSH interventions on linear growth among children aged 0-59 months. While improved WaSH interventions are critical in eliminating microbes from the child's surrounding, our study did not establish any significant benefit of WaSH and nutrition integration. We therefore, recommend the following:

i. Apply other recommendations as outlined in the proposed DSD model above.

ii. Further research to quantify the complementary effect of WaSH and nutrition co-programming to inform future policy.

f. Mainstream WaSH as a sustainable strategy for the control of helminths infections in the face of potential threats such as drug resistance and donor fatigue.

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APPENDIX

The Omnibus Tests of Model Coefficients

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	152.739	15	0.000
	Block	152.739	15	0.000
	Model	152.739	15	0.000

Model Summary

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	245.213[a]	0.406	0.547
a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.			

Classification Table

Classification Table					
			Predicted		
			16. Has there been any diarrhea complaints in the past 2 weeks?		
Observed			Yes	No	Percentage Correct
Step 1	16. Has there been any diarrhea complaints in the past 2 weeks?	Yes	91	31	74.6
		No	20	151	88.3
	Overall Percentage				82.6

a. The cut value is .500

PART 1- HIV-EXPOSED INFANT BIOMEDICAL DATA

CLIENT IDENTIFICATION DETAILS

HEI Reg. Number: EXP_____

Date of Birth:_____

Birth Weight:_____

Guardian Name:_____

Physical Address:_____

_____

Mobile Telephone Number_____

Caregiver agreed to be followed_up ____Yes_____No_____

DEMOGRAPHIC DATA

1. What is your age? (Mother or Caregiver's age)

   a. 15-24 years old
   b. 25-34 years old
   c. ≥35 years old

2. What is your ethnicity?

   a. Chewa
   b. Tumbuka
   c. Yao
   d. Other (Specify)

3. What is your marital status?

   a. Married
   b. Single
   c. Widow
   d. Divorced

4. What is the highest level of school you have completed?

a. Primary school
b. Secondary school
c. Tertiary
d. No formal school

5. What is your employment status?

a. Employed
b. Self-employed
c. Unemployed
d. Retired

CLIENT HIV INFECTION STATUS

6. What is the nature of the practitioner who conducted child delivery?

a. Skilled birth attendant
b. Unskilled birth attendant
c. Other (Specify)_____

7. What is the mother's ART status during pregnancy?

a. Alive, on ART
b. Alive, not on ART
c. Unknown ART status

8. What is the mother's ART status during labor and delivery?

a. Alive, on ART
b. Alive, not on ART
c. Unknown ART status

9. What is the mother's ART status during breastfeeding?

a. Alive, on ART
b. Alive, not on ART
c. Unknown ART status

10. What is the child's HIV infection status

a. Positive
b. Negative with on-going risk
c. Negative and no longer at risk

11. If child's HIV infection status confirmed, is the child on ART?
    a. Yes
    b. No
    c. Unknown

12. How long did it take to have test results from the laboratory (turn-around time [TAT])?
    a. < 14 days (Short TAT)
    b. > 14 days (Long TAT)
    c. Unknown duration (No documentation)

13. What is the child's immunization status?

    a. Good
    b. Poor
    c. Unknown

CLINICAL MONITORING

14. Is there any evidence of hospitalization at any point since child birth?
    a. Yes
    b. No
    c. Unknown

15. (*If yes to 14*) What is the frequency of child hospitalizations?

    a. Once
    b. More than once
    c. Frequently

16. Has there been any diarrhea complaints in the past 2 weeks?
    a. Yes
    b. No
    c. Unknown

17. Did the child develop malnutrition (based on weight/height or length/age or MUAC) at any point in time during the 24 months follow-up period

a. Yes
b. No
c. Unknown

ADHERENCE TO GOOD PRACTICES AND SCHEDULED APPOINTMENTS AND MEDICATIONS

18. What is the child' adherence to Nevirapine prophylaxis from birth to 6 weeks of age?
    a. Good adherence
    b. Poor adherence
    c. Unknown (No documentation)

19. What is the child's adherence to CPT from 6 weeks to date?
    a. Good adherence
    b. Poor adherence
    c. Unknown (No documentation)

20. What is the young infant feeding practice from birth to 6 months of age?

    a. Exclusive breastfeeding
    b. Mixed feeding
    c. Complementary feeding
    d. Replacement feeding

FOLLOW-UP OUTCOME

BARRIERS/ FACILITATORS OF ACCESS TO SERVICES

21. Are you currently enrolled with any health insurance cover?

    a. Yes
    b. No
    c. Not sure

22. Has the lack of health insurance cover led you to miss a scheduled appointment with a

Doctor?

a. Yes
b. No
c. Not sure

23. Has the lack of health insurance cover led you not purchase other prescribed medicines

a. Yes
b. No
c. Not sure

24. Has the lack of transport money led you to miss scheduled appointment with a Doctor?

a. Yes
b. No
c. Not sure

25. Has the lack of money ever led you to seek other forms of care (spiritual or traditional) other than the conventional methods of healing?

a. Yes
b. No
c. Not sure

PART 2- SANITATION DESCRIPTORS

AVAILABILITY

26. Does the household use a toilet?

a. Yes
b. No
c. Not sure

27. Where is the toilet facility located?

a. Inside the house **(Good level of service)**
b. In the compound (**Intermediate level of service)**
c. In the neighbor's compound/ In a public place **(poor level of service)**
d. Use open space /Not using any toilet facility **(No level of service)**

28. How can you describe the type of toilet facility on the sanitation ladder?

a. Improved (**Good level of service)**
b. Shared (**Intermediate level of service)**
c. Unimproved **(poor level of service)**
d. Open Defecation **(No level of service)**

PHYSICAL ACCESSIBILITY

29. How is the user safety and security while accessing the sanitation facility?

a. Safe and secure (the physical integrity of users while accessing the facility is guaranteed) **(Good level of service)**
b. Partially secure (**Intermediate level of service)**
c. Unsecure (the physical integrity of users while accessing the facility is not guaranteed) **(poor level of service)**

30. How accessible is this toilet facility (Continuity of use of the latrine)?

a. Full access (all day and night) **(Good level of service)**
b. Partial access (the facility is available at least 18 hours per day) (**Intermediate level of service)**
c. Limited access (the facility is available less than 18 hours per day) **(poor level of service)**

31. How suitable is the toilet facility across gender and different age groups?
    a. Suitable for all (men, women, girls and boys of all ages) **(Good level of service)**
    b. Not suitable for particular population groups (the elderly, women, girls or boys of all ages, etc.) **(poor level of service)**

QUALITY AND SAFETY

32. What is the sanitary condition of the latrine (presence of insects, unpleasant smell, cleanliness?)
    a. Adequate sanitary conditions (no insects, no smell, adequately clean) **(Good level of service)**
    b. Acceptable sanitary conditions (few insects, slight unpleasant smell, some dirt but no feces or urine) (**Intermediate level of service)**
    c. Poor sanitary conditions (insects, strong unpleasant smell, feces or urine on the floor) **(poor level of service)**

33. How would you describe the general latrine standards (Condition of lined pit and upper superstructure?)

    a. Adequate latrine standards (lined pit, undamaged superstructure) **(Good level of service)**
    b. Acceptable latrine standards (inadequate lining of the pit and damaged superstructure) (**Intermediate level of service)**
    c. Poor latrine standards (no lined pit, no superstructure) **(poor level of service)**

34. Is there a hand-washing facility and soap in the vicinity of the latrine?

a. Hand-washing facility with water and soap / ash **(Good level of service)**
d. Hand-washing facility with no soap / ash (**Intermediate level of service)**
b. Hand-washing facility with no water / No hand-washing facility **(poor level of service)**

35. What is your comment on safe management and disposal of human urine and faces?
a. Safe disposal of excreta (disposed in situ or treatedoff-site) **(Good level of service)**
b. Safe removal / transport ofexcreta off-site, with no treatment (**Intermediate level of service)**
e. Unsafe emptying of pits / unsafe transport of excretaoff-site / inadequate containment of feces and urine **(poor level of service)**

36. What is the level of hygiene practices in the latrine (availability of water and materials for anal and genital cleansing, menstrual hygiene management, hygienic disposal of cleansing materials and menstrual products)

a. Adequate hygienic practices (availability of water and cleansing materials, adequatemenstrual hygiene management, hygienic disposal of cleansing and menstrual products) **(Good level of service)**
b. Acceptable hygienicpractices (**Intermediate level of service)**
c. Poor hygienic practices (no water / cleansing materials, inadequate menstrual hygienemanagement, unhygienic disposal of cleansing and menstrual products **(poor level of service)**

37. Describe your family sanitation status over the past 24 months

a. Much the same
b. Much improved
c. Has become worse

PART 3- DRINKING WATER LADDER

38. What is the household's access to drinking water supply based on the following service

level descriptors?

a. Drinking water from an improved water source that is accessible on premises, available when needed and free from fecal and chemical contamination **(Safely managed)**
b. Drinking water from an improved source, and collection time is not more than 30 minutes for a roundtrip including queuing **(Basic service level)**
c. Drinking water from an improved source for which collection time exceeds 30 minutes for a roundtrip including queuing **(Limited service level)**
d. Drinking water from an unprotected dug well or unprotected spring, river or irrigation canal **(Unimproved service level)**

39. Describe your family drinking water ladder (safety/ access) over the past 24 months

a. Much the same
b. Much improved
c. Has become worse

PART 4– SIMPLE POBERTY SCORECARD

POVERTY ASSESMENT TOOL

	Indicator	Response	Points	Score
40	How many members does the household have?	a. ≥7	0	
		b. 6	4	
		c. 5	10	
		d. 4	15	
		e. <4	31	
41	Is the oldest (female) head able to read and write in Chichewa or English?	a. No	0	
		b. Yes, only Chichewa	4	
		c. Yes, English (regardless of Chichewa)	8	
		d. No female head (spouse)	13	
42	The floor of the main dwelling is predominantly made of what material?	a. Smoothed mud or sand	0	
		b. Smooth cement, wood, tile or other	8	
43	The outer walls of the main dwelling house are predominantly made of what material	a. Mud (*yomata*) or grass	0	

		b. Mud brick (unfired)	5
		c. Compacted earth (*yamdindo*),burnt bricks, concrete, wood, iron sheets or other	8
44	The roof of the main dwelling is predominantly made of what material?	a. Grass, plastic sheets or other	0
		b. Iron sheets, clay tiles or concrete	3
45	What kind of toilet facility does the household use?	a. None, traditional latrine without roof shared with other households	0
		b. Traditional latrine without roof only for household members	4
		c. Traditional latrine with roof, shared with other households	4
		d. Traditional latrine with roof, only for household members, VIP latrine or flush toilet	6
46	What is the household's main source of lighting fuel	a. Collected firewood, purchased firewood, grass or gas	0
		b. Paraffin or other	8
		c. Battery/ dry cell (torch), candles or electricity	13
47	Do any members of the household sleep under a bed net to protect against mosquitoes at some time during the year?	a. No	0
		b. Yes	5
48	Does the household own any table?	a. No	0
		b. Yes	9
49	Does the household own any beds?	a. No	0
		b. Yes	4

Table: The Calculated Poverty Index Table for Households for HEI

Serial No.	How many members does the household have?	Is the oldest (female) head able to read and write in Chichewa or English?	The floor of the main dwelling is predominantly made of what material?	The outer walls of the main dwelling house are predominantly made of what material	The roof of the main dwelling is predominantly made of what material?	What kind of toilet facility does the household use?	What is the household's main source of lighting fuel	Do any members of the household sleep under a bed net?	Does the household own any table?	Does the household own any beds?	Household Poverty Score	Likelihood of being below the poverty line (%)
1	0	4	0	0	0	0	0	0	0	0	**4**	**100**
2	5	4	0	0	0	0	0	0	0	0	**9**	**86.9**
3	5	4	8	8	3	4	0	5	9	4	**50**	**20.7**
4	0	4	0	0	0	4	0	5	0	4	**17**	**85.6**
5	4	0	0	0	0	4	0	5	0	0	**13**	**85.9**
6	0	4	0	0	0	4	0	0	9	0	**17**	**85.6**
7	0	4	0	0	0	4	0	5	0	0	**13**	**85.9**
8	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
9	0	0	0	5	3	4	0	0	0	0	**12**	**85.9**
10	0	0	0	0	0	4	0	5	0	0	**9**	**86.9**
11	0	4	0	5	3	4	0	0	0	0	**16**	**85.6**
12	5	4	8	8	3	6	0	0	0	0	**34**	**55.1**
13	0	0	0	5	3	4	0	5	0	0	**17**	**85.6**
14	0	4	0	0	0	4	0	0	0	0	**8**	**86.9**
15	15	4	0	8	3	4	0	5	0	0	**39**	**47.1**
16	4	0	8	5	3	4	0	5	0	0	**29**	**64.8**
17	15	8	0	5	0	4	0	0	0	0	**32**	**55.1**
18	0	0	0	0	0	0	0	0	0	0	**0**	**100**
19	0	0	0	5	0	0	0	0	0	4	**9**	**86.9**
20	0	4	0	5	0	0	0	0	0	0	**9**	**86.9**

Serial No.	How many members does the household have?	Is the oldest (female) head able to read and write in Chichewa or English?	The floor of the main dwelling is predominantly made of what material?	The outer walls of the main dwelling house are predominantly made of what material	The roof of the main dwelling is predominantly made of what material?	What kind of toilet facility does the household use?	What is the household's main source of lighting fuel	Do any members of the household sleep under a bed net?	Does the household own any table?	Does the household own any beds?	Household Poverty Score	Likelihood of being below the poverty line (%)
21	31	8	0	8	0	6	0	5	0	0	**58**	**16.7**
22	15	4	8	8	3	4	13	5	0	4	**64**	**12.8**
23	4	8	0	5	3	4	0	0	0	0	**24**	**77.6**
24	4	8	0	5	3	4	0	5	0	0	**29**	**64.8**
25	0	4	0	5	0	4	0	5	9	0	**27**	**64.8**
26	4	4	0	5	0	4	13	5	0	0	**35**	**47.1**
27	4	4	0	0	0	0	0	0	0	0	**8**	**86.9**
28	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
29	0	4	8	8	3	4	0	0	0	0	**27**	**64.8**
30	5	8	0	8	0	4	13	5	0	0	**43**	**39.6**
31	31	8	8	8	3	4	0	5	9	4	**80**	**1.5**
32	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
33	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
34	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
35	0	4	0	0	0	0	0	0	0	0	**4**	**100**
36	15	4	8	8	3	4	13	5	9	4	**73**	**4.2**
37	0	4	0	5	3	6	0	0	0	0	**18**	**85.6**
38	5	8	8	5	0	4	13	5	0	4	**52**	**20.7**
39	5	4	0	0	0	4	0	0	0	0	**13**	**85.9**
40	4	4	0	5	0	4	0	0	0	0	**17**	**85.6**
41	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
42	5	4	8	5	3	4	13	5	0	4	**51**	**20.7**
Serial No.	**How many members**	**Is the oldest**	**The floor of the main**	**The outer walls of the**	**The roof of the main**	**What kind of**	**What is the household's**	**Do any members**	**Does the household**	**Does the household**	**Household Poverty**	**Likelihood of being**

	does the household have?	(female) head able to read and write in Chichewa or English?	dwelling is predominantly made of what material?	main dwelling house are predominantly made of what material	dwelling is predominantly made of what material?	toilet facility does the household use?	main source of lighting fuel	of the household sleep under a bed net?	own any table?	own any beds?	Score	below the poverty line (%)
43	4	4	8	5	3	4	13	0	0	4	**45**	**32.5**
44	4	4	0	8	0	4	13	0	0	0	**33**	**55.1**
45	31	4	8	5	3	4	13	5	9	4	**86**	**0.8**
46	31	8	8	5	3	4	13	5	0	4	**81**	**1.5**
47	5	4	8	5	3	4	13	5	9	4	**60**	**12.8**
48	4	0	0	0	0	0	0	0	0	0	**4**	**100**
49	4	4	0	5	0	4	0	0	0	0	**17**	**85.6**
50	4	4	0	0	0	0	0	0	0	0	**8**	**86.9**
51	0	4	0	5	0	0	0	0	0	0	**9**	**86.9**
52	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
53	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**
54	31	4	8	8	3	4	13	5	0	4	**80**	**1.5**
55	15	0	0	0	3	4	13	0	0	0	**35**	**47.1**
56	15	8	0	5	0	4	13	5	0	0	**50**	**20.7**
57	15	8	0	8	3	4	13	5	9	4	**69**	**7.2**
58	5	0	0	0	0	0	13	5	0	0	**23**	**77.6**
59	4	0	0	0	0	0	13	0	0	0	**17**	**85.6**
60	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
61	5	0	0	0	0	0	0	0	0	0	**5**	**86.9**
62	0	0	0	5	3	0	0	0	0	0	**8**	**86.9**
63	0	0	0	0	0	0	0	0	0	0	**0**	**100**
64	0	0	0	0	0	0	0	0	0	0	**0**	**100**
Serial No.	**How many members does the household**	**Is the oldest (female) head able**	**The floor of the main dwelling is predominantly**	**The outer walls of the main dwelling house are**	**The roof of the main dwelling is predominantly**	**What kind of toilet facility**	**What is the household's main source of**	**Do any members of the household**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty**

	have?	to read and write in Chichewa or English?	made of what material?	predominantly made of what material	made of what material?	does the household use?	lighting fuel	sleep under a bed net?				line (%)
65	5	0	0	0	0	0	0	5	9	4	**23**	**77.6**
66	4	0	0	0	0	0	0	0	0	0	**4**	**100**
67	5	0	0	0	0	0	0	0	0	4	**9**	**86.9**
68	5	0	0	0	0	0	0	5	0	0	**10**	**85.9**
69	15	0	0	0	0	0	0	0	0	0	**15**	**85.6**
70	31	4	0	0	0	4	13	5	0	0	**57**	**16.7**
71	5	0	0	5	3	0	0	0	0	4	**17**	**85.6**
72	0	0	8	5	3	0	13	0	0	4	**33**	**55.1**
73	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
74	5	0	0	5	0	4	13	5	0	0	**32**	**55.1**
75	4	4	8	8	0	4	13	5	9	4	**59**	**16.7**
76	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
77	4	8	0	5	0	4	13	5	0	0	**39**	**47.1**
78	5	8	0	0	0	6	13	5	0	4	**41**	**39.6**
79	0	4	0	0	0	6	13	5	0	0	**28**	**64.8**
80	0	4	0	8	3	4	13	5	0	4	**41**	**39.6**
81	5	8	8	8	3	6	13	5	9	4	**69**	**7.2**
82	0	4	0	5	0	6	13	5	0	0	**33**	**55.1**
83	4	4	8	0	0	4	13	5	9	0	**47**	**32.5**
84	15	8	8	8	3	4	13	5	0	4	**68**	**7.2**
85	5	4	8	5	3	4	13	5	9	4	**60**	**12.8**
86	5	0	0	8	0	0	0	0	0	0	**13**	**85.9**
Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**

		in Chichewa or English?		material		use?		bed net?				
87	0	4	0	5	0	0	13	5	0	0	**27**	**64.8**
88	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
89	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
90	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
91	5	8	0	8	3	4	13	5	0	0	**46**	**32.5**
92	4	0	0	0	0	0	0	0	0	0	**4**	**100**
93	5	8	8	8	3	4	13	5	9	4	**67**	**7.2**
94	5	8	0	5	0	6	13	5	0	0	**42**	**39.6**
95	5	8	8	8	3	6	13	5	9	4	**69**	**7.2**
96	4	8	8	8	3	4	13	5	0	0	**53**	**20.7**
97	4	8	8	8	3	4	13	5	9	4	**66**	**7.2**
98	15	4	0	8	3	4	13	5	9	0	**61**	**12.8**
99	5	4	0	8	0	0	13	5	9	0	**44**	**39.6**
100	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
101	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
102	0	0	0	0	0	0	0	0	0	0	**0**	**100**
103	31	8	0	0	0	4	13	5	0	4	**65**	**7.2**
104	4	0	0	5	0	0	0	0	0	0	**9**	**86.9**
105	0	0	0	0	0	0	0	0	0	0	**0**	**100**
106	31	4	8	8	3	4	13	5	0	4	**80**	**1.5**
107	31	4	0	8	3	6	13	5	9	0	**79**	**3.5**
108	31	4	8	8	3	4	13	5	9	4	**89**	**0.8**

Serial No.	How many members does the household have?	Is the oldest (female) head able to read and write in Chichewa	The floor of the main dwelling is predominantly made of what material?	The outer walls of the main dwelling house are predominantly made of what material	The roof of the main dwelling is predominantly made of what material?	What kind of toilet facility does the household use?	What is the household's main source of lighting fuel	Do any members of the household sleep under a bed net?	Does the household own any table?	Does the household own any beds?	Household Poverty Score	Likelihood of being below the poverty line (%)

		or English?										
109	15	8	8	8	3	4	13	5	0	4	**68**	**7.2**
110	31	8	0	5	0	4	13	5	9	4	**79**	**3.5**
111	31	4	0	5	0	4	13	5	9	4	**75**	**3.5**
112	31	4	8	5	3	4	0	5	9	4	**73**	**4.2**
113	0	4	0	5	0	4	13	5	9	4	**44**	**39.6**
114	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**
115	31	4	8	8	3	4	13	5	9	4	**89**	**0.8**
116	4	8	0	8	0	4	13	5	0	4	**46**	**32.5**
117	5	4	0	5	0	4	0	5	0	0	**23**	**77.6**
118	15	4	0	5	0	4	0	5	9	0	**42**	**39.6**
119	5	4	0	0	0	4	0	5	9	4	**31**	**55.1**
120	0	0	0	5	3	4	13	5	0	0	**30**	**55.1**
121	31	4	0	8	0	4	13	5	0	0	**65**	**7.2**
122	5	8	0	5	0	4	13	5	0	0	**40**	**39.6**
123	15	0	0	8	0	4	13	5	0	4	**49**	**32.5**
124	31	4	0	5	0	4	13	5	0	4	**66**	**7.2**
125	31	8	0	5	0	4	13	5	0	0	**66**	**7.2**
126	15	4	0	5	0	4	13	0	0	0	**41**	**39.6**
127	5	4	0	5	0	0	0	0	0	0	**14**	**85.9**
128	31	4	8	8	3	4	0	5	9	4	**76**	**3.5**
129	5	8	8	8	3	4	13	5	9	4	**67**	**7.2**
130	0	0	0	0	0	6	13	0	0	0	**19**	**85.6**

Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**

131	4	4	0	5	3	4	13	5	9	4	**51**	**20.7**
132	4	4	0	0	0	6	13	0	0	4	**31**	**55.1**
133	5	0	0	0	0	0	0	0	0	0	**5**	**86.9**
134	0	0	0	0	0	0	0	0	0	0	**0**	**100**
135	0	0	0	0	0	0	0	0	0	0	**0**	**100**
136	4	0	0	0	0	0	0	5	0	0	**9**	**86.9**
137	15	4	8	8	3	4	13	5	9	4	**73**	**4.2**
138	15	4	0	5	0	4	0	5	0	4	**37**	**47.1**
139	15	4	0	5	0	4	0	5	0	4	**37**	**47.1**
140	5	0	0	0	0	0	0	5	0	0	**10**	**85.9**
141	5	4	0	8	3	0	13	5	0	0	**38**	**47.1**
142	5	4	0	5	0	6	13	5	0	4	**42**	**39.6**
143	31	0	8	8	0	4	13	5	0	0	**69**	**7.2**
144	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
145	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
146	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
147	15	4	8	8	3	4	13	5	9	4	**73**	**4.2**
148	5	8	8	8	3	4	13	5	9	4	**67**	**7.2**
149	5	0	0	5	0	0	0	5	0	0	**15**	**85.6**
150	31	0	0	5	0	0	0	5	0	0	**41**	**39.6**
151	31	4	0	5	0	0	0	5	0	0	**45**	**32.5**
152	4	0	0	5	0	0	0	5	0	0	**14**	**85.9**

Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**
153	5	4	0	8	0	4	13	5	9	0	**48**	**32.5**

154	31	4	8	5	3	4	13	5	0	4	**77**	**3.5**
155	5	4	0	8	3	4	0	5	0	4	**33**	**55.1**
156	4	4	8	5	3	4	13	5	0	0	**46**	**32.5**
157	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
158	31	4	0	8	0	4	13	5	0	0	**65**	**7.2**
159	0	4	0	8	0	4	13	5	0	0	**34**	**55.1**
160	5	8	0	5	0	4	13	5	0	0	**40**	**39.6**
161	15	4	0	5	0	4	13	5	0	0	**46**	**32.5**
162	31	4	0	8	0	4	13	5	0	0	**65**	**7.2**
163	4	0	0	0	0	0	0	0	0	0	**4**	**100**
164	5	0	0	5	0	0	0	5	0	0	**15**	**85.6**
165	0	0	0	0	0	0	0	0	0	0	**0**	**100**
166	31	4	8	5	3	4	13	5	9	0	**82**	**1.5**
167	31	4	8	5	0	4	13	5	0	4	**74**	**4.2**
168	0	0	0	5	3	0	13	0	0	0	**21**	**77.6**
169	5	4	0	0	0	0	0	0	0	0	**9**	**86.9**
170	31	13	8	8	3	4	13	5	9	4	**98**	**0**
171	15	13	8	8	3	4	13	5	9	4	**82**	**1.5**
172	5	13	8	8	3	4	13	5	9	4	**72**	**4.2**
173	0	8	8	8	3	4	13	5	0	4	**53**	**20.7**
174	31	13	8	8	3	6	13	5	0	4	**91**	**0.8**

Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**
175	15	0	0	5	0	4	13	5	0	0	**42**	**39.6**
176	4	0	0	5	0	4	13	5	0	0	**31**	**55.1**

177	31	4	0	5	0	4	13	5	0	0	**62**	**12.8**
178	5	4	0	0	0	4	13	5	0	0	**31**	**55.1**
179	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
180	4	0	0	0	0	4	13	5	0	0	**26**	**64.8**
181	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
182	0	0	0	8	0	0	13	5	0	0	**26**	**64.8**
183	0	0	0	0	0	0	13	5	0	0	**18**	**85.6**
184	15	8	0	8	0	4	13	5	9	4	**66**	**7.2**
185	4	0	0	5	0	6	0	0	0	0	**15**	**85.6**
186	5	4	0	8	0	4	13	5	0	4	**43**	**39.6**
187	31	8	8	8	3	4	13	5	0	0	**80**	**1.5**
188	15	4	8	8	3	4	13	5	0	0	**60**	**12.8**
189	5	8	0	5	0	4	13	5	9	0	**49**	**32.5**
190	31	4	0	5	0	4	13	5	0	0	**62**	**12.8**
191	31	4	8	8	3	4	13	5	0	0	**76**	**3.5**
192	0	4	0	8	3	0	13	5	0	4	**37**	**47.1**
193	4	4	0	5	0	6	13	5	0	0	**37**	**47.1**
194	4	4	0	5	0	4	13	5	0	0	**35**	**47.1**
195	31	8	0	0	0	4	13	5	0	0	**61**	**12.8**
196	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**

Serial No.	How many members does the household have?	Is the oldest (female) head able to read and write in Chichewa or English?	The floor of the main dwelling is predominantly made of what material?	The outer walls of the main dwelling house are predominantly made of what material	The roof of the main dwelling is predominantly made of what material?	What kind of toilet facility does the household use?	What is the household's main source of lighting fuel	Do any members of the household sleep under a bed net?	Does the household own any table?	Does the household own any beds?	Household Poverty Score	Likelihood of being below the poverty line (%)
197	5	8	8	8	3	4	13	5	9	4	**67**	**7.2**
198	4	8	8	8	3	4	13	5	0	0	**53**	**20.7**
199	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**

200	15	8	0	5	0	4	13	5	9	4	**63**	**12.8**
201	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
202	0	4	0	8	0	4	13	5	0	0	**34**	**55.1**
203	0	4	0	8	0	4	13	5	0	0	**34**	**55.1**
204	31	4	0	5	0	4	13	5	0	0	**62**	**12.8**
205	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
206	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
207	4	4	8	8	3	4	13	5	0	0	**49**	**32.5**
208	15	4	0	5	0	4	13	5	0	0	**46**	**32.5**
209	31	4	0	5	0	4	13	5	0	0	**62**	**12.8**
210	4	4	8	8	3	4	13	5	9	0	**58**	**16.7**
211	15	8	8	8	0	4	13	5	0	0	**61**	**12.8**
212	15	8	8	8	3	4	13	5	0	4	**68**	**7.2**
213	0	4	0	5	0	4	13	5	9	0	**40**	**39.6**
214	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**
215	15	4	8	5	3	4	0	5	9	4	**57**	**16.7**
216	15	4	0	0	0	0	0	5	0	0	**24**	**77.6**
217	31	4	0	5	3	4	0	5	9	4	**65**	**7.2**
218	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**

Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**
219	4	4	0	8	3	4	0	5	9	0	**37**	**47.1**
220	5	4	0	8	3	4	0	5	9	4	**42**	**39.6**
221	5	4	0	5	3	4	0	5	0	4	**30**	**55.1**
222	15	8	8	8	3	4	13	5	0	0	**64**	**12.8**

223	15	8	8	8	3	4	13	5	0	4	**68**	**7.2**
224	15	4	0	0	0	0	13	0	0	0	**32**	**55.1**
225	0	4	0	0	0	4	13	5	9	0	**35**	**47.1**
226	5	4	8	5	3	4	0	5	9	4	**47**	**32.5**
227	31	8	8	5	3	4	13	5	9	4	**90**	**0.8**
228	5	4	0	5	3	4	0	5	0	4	**30**	**55.1**
229	4	4	8	5	3	4	0	5	9	4	**46**	**32.5**
230	5	4	0	5	0	4	0	5	0	0	**23**	**77.6**
231	15	4	8	5	3	4	0	5	9	4	**57**	**16.7**
232	31	4	0	5	0	4	13	5	0	0	**62**	**12.8**
233	5	8	8	8	3	4	13	5	9	0	**63**	**12.8**
234	15	4	8	8	3	4	13	5	9	4	**73**	**4.2**
235	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**
236	5	4	0	5	0	4	13	5	0	0	**36**	**47.1**
237	31	4	8	8	3	4	13	5	9	4	**89**	**0.8**
238	31	4	8	8	3	4	13	5	9	0	**85**	**0.8**
239	0	4	8	8	3	4	13	5	9	4	**58**	**16.7**
240	4	4	0	0	0	0	0	0	0	0	**8**	**86.9**

Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**
241	0	8	8	8	3	4	0	5	9	4	**49**	**32.5**
242	0	4	0	0	0	6	13	0	0	0	**23**	**77.6**
243	5	8	8	8	3	4	13	5	9	4	**67**	**7.2**
244	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
245	5	4	0	0	0	6	13	0	0	0	**28**	**64.8**

246	0	4	8	8	3	4	13	5	9	4	**58**	**16.7**
247	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
248	4	4	0	0	0	0	13	0	0	0	**21**	**77.6**
249	0	4	0	0	3	6	13	5	0	0	**31**	**55.1**
250	31	4	8	5	3	6	13	5	0	0	**75**	**3.5**
251	5	4	8	8	3	4	13	5	9	4	**63**	**12.8**
252	4	4	8	8	3	4	13	5	0	4	**53**	**20.7**
253	15	4	8	8	3	4	13	5	9	4	**73**	**4.2**
254	15	4	0	0	0	6	13	5	0	0	**43**	**39.6**
255	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
256	15	8	8	8	3	4	13	5	9	4	**77**	**3.5**
257	5	0	0	0	0	0	0	0	0	0	**5**	**86.9**
258	0	4	0	5	3	0	13	0	0	0	**25**	**64.8**
259	4	0	0	5	0	0	13	5	0	0	**27**	**64.8**
260	0	4	0	0	0	0	13	5	9	0	**31**	**55.1**
261	4	4	0	5	0	0	13	5	0	0	**31**	**55.1**
262	15	4	0	8	0	0	13	5	0	0	**45**	**32.5**

Serial No.	How many members does the household have?	Is the oldest (female) head able to read and write in Chichewa or English?	The floor of the main dwelling is predominantly made of what material?	The outer walls of the main dwelling house are predominantly made of what material	The roof of the main dwelling is predominantly made of what material?	What kind of toilet facility does the household use?	What is the household's main source of lighting fuel	Do any members of the household sleep under a bed net?	Does the household own any table?	Does the household own any beds?	Household Poverty Score	Likelihood of being below the poverty line (%)
263	31	8	8	8	3	4	13	5	9	4	**93**	**0.8**
264	0	4	0	5	0	0	13	5	0	0	**27**	**64.8**
265	0	4	0	0	0	0	13	5	0	0	**22**	**77.6**
266	31	0	0	5	0	0	0	0	9	0	**45**	**32.5**
267	0	0	0	0	0	0	0	5	0	0	**5**	**86.9**
268		4	8	5	3	4	0	5	9	4	**42**	**39.6**

269	5	0	0	0	0	4	0	5	0	4	**18**	**85.6**
270	0	8	8	8	3	4	13	5	9	4	**62**	**12.8**
271	31	4	0	0	0	6	0	5	0	0	**46**	**32.5**
272	0	0	0	0	0	6	0	0	0	0	**6**	**86.9**
273	5	0	0	0	0	0	0	0	0	0	**5**	**86.9**
274	15	0	0	0	0	0	0	5	0	4	**24**	**77.6**
275	5	4	0	0	0	0	0	0	0	4	**13**	**85.9**
276	5	4	0	5	3	4	0	5	0	4	**30**	**55.1**
277	4	8	8	8	3	4	0	5	9	4	**53**	**20.7**
278	31	0	0	5	0	4	0	0	0	4	**44**	**39.6**
279	4	4	0	0	0	4	0	5	9	0	**26**	**64.8**
280	0	4	8	5	3	4	0	5	0	4	**33**	**55.1**
281	31	0	0	5	0	4	0	0	0	0	**40**	**39.6**
282	15	4	8	8	3	4	0	5	0	4	**51**	**20.7**
283	31	4	8	8	3	4	0	5	0	4	**67**	**7.2**
284	31	4	0	0	0	6	13	5	0	0	**59**	**16.7**
Serial No.	**How many members does the household have?**	**Is the oldest (female) head able to read and write in Chichewa or English?**	**The floor of the main dwelling is predominantly made of what material?**	**The outer walls of the main dwelling house are predominantly made of what material**	**The roof of the main dwelling is predominantly made of what material?**	**What kind of toilet facility does the household use?**	**What is the household's main source of lighting fuel**	**Do any members of the household sleep under a bed net?**	**Does the household own any table?**	**Does the household own any beds?**	**Household Poverty Score**	**Likelihood of being below the poverty line (%)**
285	5	13	0	5	0	4	13	5	0	0	**45**	**32.5**
286	31	4	0	0	0	0	0	5	0	0	**40**	**39.6**
287	0	0	0	0	0	4	0	0	0	0	**4**	**100**
288	15	0	0	5	3	6	13	5	0	0	**47**	**32.5**
289	4	4	0	0	0	4	0	0	0	0	**12**	**85.9**
290	15	4	8	8	3	4	13	5	0	4	**64**	**12.8**
291	5	4	0	5	0	4	0	0	0	0	**18**	**85.6**

292	15	4	0	5	0	4	0	5	0	0	**33**	**55.1**
293	15	0	0	5	0	6	0	5	0	0	**31**	**55.1**

THE INFORMED CONSENT FORM FOR RESEARCH

Informed Consent Form for Participation in Research titled

'WATER AND SANITATION: AN EXPANDED RESPONSE TO ADDRESS EXPOSED INFANTS' VULNERABILITIES TO HIV/AIDS'

Part I: Introduction

I am a PhD student from Mzuzu University. I am doing an academic study to understand the adequacy of biomedical interventions for HIV exposed infants. I am also interested to look to understand whether or not sanitation and other structural determinants play a significant protective role to reduce exposed infants' vulnerability to HIV/AIDS.

Through this research, I also seek to understand whether basic sanitation at household level is influenced by the likelihood of living below the established poverty line and whether or not poverty states increase exposed infants' susceptibility to HIV within their first twenty four months of life.

I have been granted full permission by the Mzuzu University, Department of Water and Sanitation under the Faculty of Environmental Sciences. I have further gotten ethical consent from the Mzuzu University Research and Ethics Committee to proceed with this study. The study protocol has been presented to the Director of Health and Social Services, management and staff of Area 25 Health Centre, as an inception strategy and to gain access to the facility and relevant documents for the purpose of this research. The National Research Council was duly notified in writing and approved the research protocol inline with existing guidelines for academic research involving human subjects.

I therefore guarantee strict observance of bioethics and adherence to standard research operating procedures in respect for the ethical principles of autonomy, nonmaleficence, beneficence and justice. All persons working as research assistants will be nurses and health care staff who already provide treatment, care and support to the study participants.

Identification pseudo numbers will be used at all times to disguise your identity on every data entry form. Only participants who consent to home visits in writing meet recruitment criteria.

Participation in this study is entirely voluntary; as such you may choose to withdraw at any point in time without loss of benefit or any form of reprisal from any officials.

You will not be provided any incentive for participating in this study.

Sharing the Results

The knowledge that we get from this study will be shared with you and my supervisors. After this, I will publish the results so that other scholars, government and other relevant stakeholders may learn from the study.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact: Dr. Russel Chidya, Mzuzu University, Centre of Excellence in Water and Sanitation, P/Bag 201, Mzuzu 2, Cell: +265999317176 or +265884023509. You may also contact The Director of Research, Professor Wales Singini on +265999576812 and your concerns will be fully addressed.

Do you have any questions?

Part II: Certificate of Consent

I have voluntarily accepted to participate in this research

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions for clarification and have been fully satisfied with responses provided.

Print Name of Participant_____

Signature of Participant _____

Date _____

Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands the aim of the study. I confirm the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of researcher or person taking the consent_____

Date _____

Day/month/year

MZUZU UNIVERSITY

DIRECTORATE OF RESEARCH

Mzuzu University
Private Bag 201
Luwinga
Mzuzu 2
MALAWI
TEL: 01 320 722
FAX: 01 320 648

MZUZU UNIVERSITY RESEARCH ETHICS COMMITTEE (MZUNIREC)

Ref No: MZUNIREC/DOR/22/72 **13/06/22**

Elton Chavura,
Mzuzu University,
P/Bag 201,
Mzuzu.
ecchavura@gmail.com

Dear Elton,

RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL REF NO: MZUNIREC/DOR/22/72: WATER, SANITATION AND HYGIENE: AN EXPANDED RESPONSE TO ADDRESS EXPOSED INFANTS' VULNERABILITY TO HIV/AIDS?

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the Mzuzu University Research Ethics Committee (MZUNIREC) in a format that is available at the Secretariat. Once the study is finalised, you are required to furnish the Committee with a final report of the study. The Committee reserves the right to carry out compliance inspection of this approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Committee Address:
Secretariat, Mzuzu University Research Ethics Committee, P/Bag 201, Luwinga, Mzuzu 2; E-mail address: mzunirec@mzuni.ac.mw

An Expanded Response to Address Exposed Infants' Vulnerability to HIV/AIDS in Malawi

Chavura E[1,2]., Singini W[2]., Chidya R[2]., & Mbakaya B.C[3]. (2023)
[1]Swansea University, Faculty of Medicine, Health and Life Science, Wales, United Kingdom
[2]Department of Water and Sanitation, Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2, Malawi
[3]Faculty of Applied Science, University of Livingstonia. P.O. Box 37, Rumphi, Malawi

1.0 Introduction

A significant proportion of HIV-exposed infants (HEI) in Malawi live in poverty, face drinking water and hygiene challenges that impact negatively on their health. The study evaluated the potential contribution of water, sanitation and hygiene (WaSH) towards three outcomes: **diarrhea prevention, linear growth trajectory and disease progression** among HEI and people living with HIV/AIDS in Kasungu, Malawi.

2.0 Literature Review

HEIs are 4 times more at risk of diarrhea; 6 times more likely if caregiver has diarrhea and 11 times more likely to die from diarrhea (Peletz et al., 2012; Eijk et al., 2010. Access to safe water and sanitation (SDG 6) is a catalyst for meeting many of the other SDG targets including Good health and well-being (SDG 3), Economic growth (SDG 8), and Reduced inequalities (SDG 10).

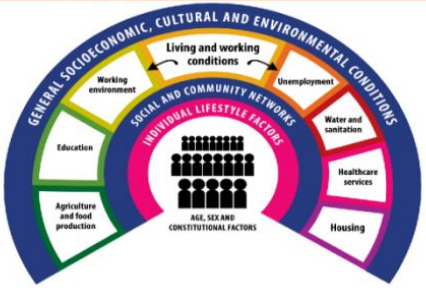

Figure 1: The Social Determinants of Health.
Source: Dahlgren and Whitehead (1991)
SDH account for up to 55% of health outcomes and clearly exceeding the contribution from medical causality (Canadian Institute of Advanced Research, 2012).

Given the dreadful state of living conditions among most PLWHA, biomedical interventions alone though necessary, are insufficient and narrow in scope; an expanded response to address exposed infants' vulnerability to HIV/AIDS offers them a more pragmatic recourse.

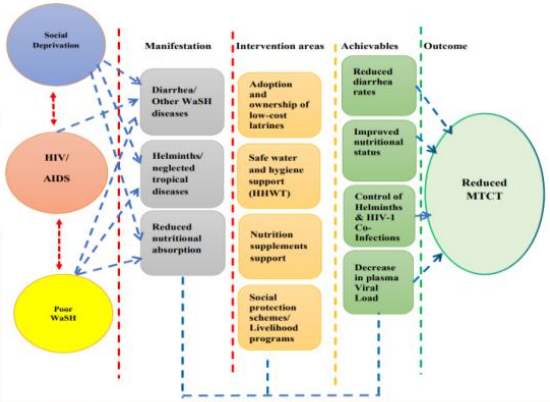

Fig 2: The Conceptual Framework
This conceptual framework postulates a need for recognition of SDH as these directly affect their vulnerability to infections

3.0 Materials and Methods

Systematic random sampling (facility and household)
Cross- sectional study of HEIs aged 6 weeks- 24 months
The sample size was generated using Slovin's (1960) formula.
$n = N / (1 + Ne\ 2)$

Systematic Literature Search
PubMed, EMBASE, PsycINFO, AMED, CINAHL, DOAJ & Google Scholar databases guided by the acceptance practice developed by PROSPERO and COCHRANE. PRISMA guidelines and a Mixed Method Appraisal Tool (MMAT) were used for aggregation and evaluation of quality of research methodology.

Data Analysis: The binary logistic regression model:
$Logit(P(Y=1)) = \beta o + \beta \times X + \varepsilon$

Outcome Measurement
Diarrhea: Watery stool, self-reported, at least once within 14 days
Stunting: Length-for-age (LAZ) z score <−2.0. Standarddeviations
HIV disease progression: V/L "<20", "<50", "<200", "undetectable", "not detected" (ND), "target not detected" (TND), "below the limit of " or "zero". Normal V/L= 20 to 75 log^{10} copies/mL of the HIV per milliliter of blood. CD4+ count =500–1,500 cells/mm3

4.0 Results

Improved WaSH practices significantly reduced diarrhea (IRR _ 0.33, 95% CI 0.24–0.46, p < 0.0001)

WaSH alone (without co-trimoxazole prophylaxis): LPR = 0.47, 95% CI: 0.30–0.73, p < 0.001).

Latrine Type and sanitary quality had no significant influence (p > 0.05).

Marital Status (OR 2.8; 95% CI 1.1-6.9)

Education (OR 14.9; 95% CI 2.8-77.4)

Improved Income (OR 0.1; 95% CI 0.1-0.3)

Employment Status (OR 2.5; 95% CI 1.1-5.6)

Mean HT/Age Z-Score was insignificant (0.01, 95% CI-0.16 to 0.18).

Viral Load : 5.01 log^{10} vs. 3.41 log^{10}, p < 0.001. The effect range:5.28 log^{10} copies/mL and 4.67 log^{10} copies/mL, (p < 0.05) after treatment.

CD4+ T-Lymphocyte Count
Insignificant difference between co-infection groups relative to those with HIV infection alone.

5.0 Discussion

- The combined effect of **co-trimoxazole/WaSH** is significantly higher than when each one of them were to be offered alone.
- **Concurrent helminth** infections may damage immune control, resulting in escalating V/L
- Latrines protect from diarrhea **regardless of whether they are improved**.
- **Better income, access to healthcare, WaSH, education and employment** are significant predictors of diarrhea. However, stunting has multifaceted causality and WaSH alone couldn't stimulate linear growth.
- The "Global strategy to combat helminths aligns with the SDG 6.1 and 6.2 on drinking water and sanitation. Helminths generally afflict the world's poorest households living in remote rural areas and urban slums (WHO, 2011). The diseases can be effectively controlled through sound WaSH interventions.

6.0 Recommendations

- **Adoption of Low-cost Latrines**- a step towards the progressive realization of SDGs (3,6,10) as they could be attained using the most cost-effective means.
- **Social Protection Schemes** to cushion HIV socioeconomic impact.
- **Social Prescribing Model (Public/PVT Partnership)** to enhance access to non-clinical services.
- **Differentiated Service Delivery Model** of care to integrate WaSH/HEI follow up with IMCI village clinics to combat sub-optimal retention in HIV care.
- **Basic care packages** for HEI (water treatment, water vessel, water filters, anti-bacterial soap and oral rehydration salt).

Presented at 2023 Research and Best Practices Dissemination Conference

MZUZU UNIVERSITY

Private Bag 201
Luwinga Mzuzu 2

Tel: +265 1 320 722/575

19th October 2023

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This is to certify that ELTON CHIMWEMWE CHAVURA has completed the Doctor of Philosophy (Ph.D) Thesis [Sanitation] offered at the *[Department of Water and Sanitation], [Faculty of Environmental Science].*

The PG research focused on

Water and Sanitation: An Expanded Response to Address Exposed Infants' Vulnerability to HIV/AIDS

We the undersigned confirm and testify completion of the stated conditions by the above–mentioned PG candidate, and that the Thesis can be examined internally and externally.

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