THREE ESSAYS ON INFANT AND YOUNG CHILD FEEDING AND CHILD HEALTH OUTCOMES IN SUB-SAHARAN AFRICA: AN EPIDEMIOLOGY AND POLICY ANALYSIS

by

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ABSTRACT

LILIAN OUJA ADEMU. Three Essays on Infant and Young Child Feeding and Child Health Outcomes in Sub-Saharan Africa: An Epidemiology and Policy Analysis
(Under the direction of DR. LISA SCHULKIND)

Exclusive breastfeeding in the first six months of life and complementary breastfeeding up to 24 months is encouraged to ensure optimal infant and young child nutrition and health. The WHO and UNICEF emphasize these optimal Infant and Young Child Feeding (IYCF) practices, especially for regions of the world where extensive child nutrition and healthcare support is lacking or inaccessible. This dissertation explores the epidemiology of IYCF practices and child health outcomes in sub-Saharan Africa. It also examines the status of IYCF policies and programs in this relatively less studied region of the world. I use publicly available data from the Nigerian Demographic and Health Survey (NDHS) and the WHO/UNICEF Breastfeeding Collective scorecard to answer important questions explored across three studies.

The first study examines the long-term impact of different durations of breastfeeding on child health outcomes post-infancy. The second study investigates the relationships between household living environmental conditions and IYCF practices, and how this complex relationship impacts child health outcomes. The third and last study describes the status and implementation of IYCF programs and policies across countries in the region. This is to help policymakers understand the gaps and challenges that would need to be overcome if the region is to meet global and world health assembly (WHA) targets on child nutrition and health.

Results from the first study suggest that longer durations of breastfeeding are associated with fewer incidents of acute illnesses post-infancy at 24 to 59 months; demonstrating the long-term protective effect of breast milk from illnesses that contribute to the high under-five mortality rates recorded for decades in sub-Saharan Africa. An important finding from the

second study is that the relationship between exclusive breastfeeding, household living environmental conditions, and acute health outcomes in infancy is complex. The results suggest that the efficacy of exclusive breastfeeding in reducing recent incidents of diarrhea and acute respiratory illness is strongest for infants living in households with poor Water, Sanitation, and Hygiene (WaSH) facilities and inadequate building materials respectively. Lastly, results from the third study indicate that sub-Saharan Africa as a region is yet to meet global and WHA targets on the implementation of many IYCF policies and programs.

These findings have implications for child nutrition and health outcomes especially for a region already disproportionately impacted by high under-five mortality rates. The findings from this dissertation would help in the design and implementation of policies specifically tailored to deal with some of the challenges that are unique to this region of the world. Any policy prescription to improve child nutrition and health outcomes for the region would need to first focus on the recommended policies that have been poorly implemented. It must also strategically promote the practice of exclusive breastfeeding in the first six months of life and longer durations of any breastfeeding by targeting communities where sub-optimal living conditions are pervasive.

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In conclusion, this dissertation represents the culmination of years of hard work, perseverance, and the collective effort of many individuals. I am truly grateful to every person who has contributed to this milestone in my academic journey, Thank you all for your invaluable, support, encouragement, and belief in me. Your contributions have shaped my research and enriched my personal and professional growth.

DEDICATION

I dedicate this work to God Almighty and the memory of my loving father, Innocent Ocheibi Ademu. He would have been proud of me.

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INTRODUCTION

Optimal Infant and Young Child Feeding (IYCF) practices include exclusive breastfeeding for the first 6 months and adequate complementary feeding beyond six months until a child is 24 months. The World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months and adequate complementary feeding beyond six months until a child is 24 months old (Mohammed et al., 2023). These practices play vital roles in reducing morbidity and mortality in children under five years of age (WHO, 2009; 2017).

Sub-Saharan Africa still accounts for the highest reported cases of child morbidity and mortality with many countries in the region lacking extensive and adequate health infrastructure (Sharrow et al., 2022). Further, acute illnesses account for some of the leading causes of childhood morbidity and mortality in under-five-aged children in the region (WHO, 2022). Breastfeeding is a highly recommended and uniquely suited infant nutrition and health intervention for countries lacking extensive health infrastructure (Brenoe et al., 2022; Adeyinka et al., 2020; UNICEF, 2020; Roberts et al., 2013). Yet, research on IYCF in the region has focused more on the determinants of optimal IYCF practices (Anin et al, 2020; Agho et al, 2019; Ogbo et al., 2015).

Studies that have explored the efficacy of optimal IYCF practices in reducing acute health outcomes in LMICs; especially in sub-Saharan Africa, are few (Nigatu et al., 2019; Khan & Islam, 2017). Most studies that have demonstrated the positive effect of breastmilk in reducing the frequency of acute health conditions like acute respiratory infection (ARI), otitis media, gastroenteritis, conjunctivitis, and urinary tract infection in childhood were conducted in developing countries (Frank et al, 2019; Duijts et al., 2010; Ladomenou et al., 2010; Cushing et al., 1998). Also, while research on the short-term benefits of breastfeeding on child health has

been extensive, relatively few have examined the long-term benefits (Horta, 2019; Yamakawa et al., 2015); especially in sub-Saharan Africa.

Short-term benefits are the immediate benefits a child enjoys while they are being breastfed while the long-term benefits are the associated benefits after breastfeeding has stopped (Frank et al., 2019). Few studies have examined the long-term impact of breastfeeding duration on acute health outcomes in childhood (Frank et al., 2019; Pattison et al., 2019, Chantry et al., 2006). Available studies on the long-term benefits of breastfeeding have also focused on chronic and non-communicable diseases such as obesity, diabetes, cancer, and cardiovascular diseases in young adulthood (Lodge et al., 2015; Izadi et al., 2013; Horta et al., 2007; Kwan et al., 2004; Leeson et al., 2001). The limited research on the temporal benefits of breastfeeding on acute health outcomes in early childhood, and the limited number of studies in this domain from developing countries leave some gaps in our current understanding of the relationship between breastfeeding and acute health outcomes in early childhood.

Also, the type of water, sanitation, and built environment children are exposed to impact their health outcomes. Many acute illnesses in infancy and childhood have been associated with the poor living environmental conditions that characterize slums and suboptimal housing in developing countries (Sheuya et al., 2007). Living environmental conditions of sanitation which comprises the source of water, type of sanitation, and hygiene (WaSH), and the built environment, have been estimated to account for 25% of all preventable diseases (Sheuya et al., 2007). Studies conducted in developing countries including sub-Saharan Africa have linked the quality of sanitation facilities and built living environments to diarrhea and ARIs (Aftab et al., 2022; Akinyemi & Morakinyo, 2018). Good WaSH which comprises the availability of improved toilets, water, and proper stool disposal protects infants from enteric pathogens outside

of their living environment (Baker et al., 2016; Brown et al., 2013). Similarly, adequate walls, floors, and roofing materials play an intermediating role in reducing the exposure of infants to vectors or pathogens that predispose infants to acute health outcomes like malaria fever, ARIs, and pneumonia (Sikalima et al., 2021; Keleb et al., 2020; Yaya et al., 2018; Ippolito et al., 2017).

When considered together, both the type of infant feeding (exclusive or non-exclusive breastfeeding) and the type of living environmental conditions infants are exposed to are important determinants for infant or child health. Breastmilk contains a rich amount of nutrients and immunogenic factors which improve an infant's ability to resist infection (Jackson & Nazar, 2006). Thus, exclusive breastfeeding compared to non-exclusive breastfeeding may provide greater protection to infants living in highly inadequate or suboptimal living environments. Also, because appropriate WaSH and built living environments protect infants by reducing their exposure to pathogenic organisms or vectors that increase their risk for acute health outcomes, an adequate living environment may be most significant for infants not exclusively breastfed. Lastly, both exclusive breastfeeding and improved living environmental conditions combined may offer more protection compared to other sub-optimal levels of breastfeeding and environmental conditions.

Few studies have explored these gaps most especially within the sub-Saharan African context; pointing to the need for more research considering a broader scope of risk factors infants associated with infant and young child health. The nature of the relationships and interactions between environmental conditions, infant feeding, and health outcomes is something that should be further explored. This is even more salient for regions of the world with a high prevalence of sub-optimal living environmental conditions as well as the highest under-five mortality rates.

The adoption of appropriate and optimal IYCF practices has great potential for decreasing child morbidity and mortality rates globally (Victora et al., 2016). In 2002, the WHO and the United Children's Emergency Fund (UNICEF) jointly developed the Global Strategy for Infant and Young Child Feeding. The strategy provides a framework for action in essential policy areas aimed at improving through optimal feeding, infant and young child nutritional status growth, development health, and overall survival.1 The strategy which is intended as a guide for action for all countries identifies programs and policies with positive impacts and clearly states the responsibilities of governments and non-governmental organizations in meeting the overall aim of improving IYCF.

Despite readily available data on the progress countries have made on the implementation of recommended IYCF policies and programs, there is a paucity of research on the trends and status of these policies and programs and their implications for child morbidity and mortality in sub-Saharan Africa. For progress to be made on child nutrition and health outcomes in this region, an examination of the implementation of recommended programs and policies that promote, protect, and support optimal IYCF practices in the region is crucial.

This research would be guided by the Social Ecological Model (SEM). The central concept of the SEM is that health behaviors and outcomes are influenced by a dynamic interplay between the individual, community, physical, social, and policy environment (Israel et al., 2008; Sallis et al., 2015; Wallerstein et al., 2017). Thus, the framework can be used to conceptualize the relationship between IYCF practices, living environmental conditions, policies, and child health outcomes. It also provides constructs to explain why and how individuals practice certain behaviors under the influence of different levels of social, economic, and physical environments.

[1] https://www.globalbreastfeedingcollective.org/global-strategy-infant-and-young-child-feeding

The constructs within the framework are useful for identifying important mechanisms and concepts as well as barriers and facilitators at each level to guide the three studies explored in this dissertation. Furthermore, understanding these constructs is useful for making policy recommendations to promote optimal IYCF practices and improve child health outcomes. Prior studies on IYCF practices have used the SEM to examine breastfeeding practices (Reeves & Woods-Giscombe, 2015; Hector et al., 2005) and to plan and analyze interventions that promote optimal IYCF (DeLorme et al., 2018; Sandow et al., 2022). Existing research has also applied the SEM to examining relationships between infant feeding and child health outcomes (Munn et al., 2016) and to develop interventions to promote optimal IYCF practices (Johnson et al., 2015)

Utilizing this framework, this dissertation would provide new evidence that informs some of the uncertainty currently in the research on IYCF. To my knowledge, no study has examined the long-term benefits of any breastfeeding duration on recent incidents of acute illnesses during early childhood in sub-Saharan Africa. Furthermore, research on how living environment conditions interact with breastfeeding to impact acute health outcomes in children, and how policies on IYCF have been implemented in the region is lacking. To explore these gaps, I utilize data from the Nigerian Demographic and Health Survey (NDHS) and the WHO/UNICEF Breastfeeding Collective scorecard.

Using the NDHS data, the first study provides new evidence on the temporal benefits of breastfeeding duration on acute illnesses in early childhood. Most importantly it would be from a region of the world where research of this type is limited. The second study also utilizes the NDHS data to examine how the living environmental conditions in sub-Saharan Africa intersect with child health outcomes in breastfed infants.

Nigeria is uniquely suited as a case study for the region for many reasons. First, it currently accounts for the highest number of deaths from acute health outcomes in children under five years of age in sub-Saharan Africa (Sharrow et al., 2022; UNICEF, 2020). It is also the most populous country in the region with a population of over 200 million. Nigeria also has a lot of ethnic and religious diversity which it shares with other countries in the region. Furthermore, it has experienced a mix of democratic and authoritarian governments since its independence in 1960 and thus shares a lot of political and developmental challenges common in many parts of the region.

The third study analyzes data on the progress made by 49 countries in the region on the policies recommended in Global Strategy for the promotion of optimal IYCF practices. This data is collated from the WHO/UNICEF Breastfeeding Collective scorecard for 2022. The goal is to provide the most recent evidence on the state of implementation and adoption of recommended policies to promote IYCF and improve child nutrition and health outcomes in sub-Saharan Africa.

The findings from these studies have policy implications for nutrition and short and long-term health outcomes of children living in the region. As stated earlier, Nigeria is uniquely suited as a case study for the sub-Saharan region because not only does it account for the highest under-five mortality rates in the region, but it also shares similar cultural, socio-economic, political, and demographic characteristics with other countries in the region. The first study expands our knowledge of the relationship between breastfeeding duration and child health outcomes. An examination of the effects of the long-term benefits of breastfeeding duration for children living in sub-Saharan Africa would help in the design of more effective interventions or programs that promote optimal IYCF.

The second study provides a nuanced understanding of how IYCF practices intersect with living environmental conditions to impact acute illnesses in childhood in sub-Saharan Africa. The findings from this study are important for the design of more effective and efficient interventions that consider a broader spectrum of the challenges that are unique to this region of the world.

Lastly, a clear picture of the implementation and adoption of IYCF policies and programs in the region would ensure that both national and international funds allocated for mitigating the scourge of child malnutrition and mortality in the region are properly allocated so that they receive adequate returns on investment. I sincerely hope this study opens new lines of inquiry and discourse that will help improve our overall knowledge in this domain with the ultimate objective of improving the overall health outcomes of under-five children living in sub-Saharan Africa.

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CHAPTER 1: LONG-TERM EFFECTS OF BREASTFEEDING DURATION: AN ANALYSIS OF ACUTE HEALTH OUTCOMES IN CHILDREN

Introduction

Acute illnesses remain one of the leading causes of childhood morbidity and mortality in under-five-aged children in sub-Saharan Africa (WHO, 2022). Well known for its rich content of nutrients, and antimicrobial, anti-inflammatory, and immune factors, breastfeeding is a well-recognized and uniquely suited infant nutrition and health intervention in countries lacking extensive health infrastructure and nutrition support (Adeyinka et al., 2020; UNICEF, 2020; Roberts et al., 2013).

The health benefits of breastfeeding have been extensively investigated (Nigatu et al., 2019; Santos et al., 2015; Quigley et al., 2007). Past studies have demonstrated the efficacy of optimal infant and young child feeding practices like exclusive breastfeeding and longer durations of breastfeeding in reducing child morbidity and mortality (Mihrshah et al., 2008; Hatakka et al., 2010). Few of these studies, however, have been conducted in Low- and Middle-Income Countries (LMICs). Especially in sub-Saharan Africa; a region contributing the highest to the global under-five mortality rates (WHO, 2022; Nigatu et al.,2019; Khan & Islam, 2017).

Short-term benefits of breastfeeding are the immediate benefits a child enjoys while they are being breastfed while the long-term benefits are the associated benefits after breastfeeding has stopped (Frank et al., 2019). Though the short-term benefits of breastfeeding have been extensively established (Chantry et al., 2006; Duijts et al. 2010), comparatively few studies have explored the long-term benefits (Pattison et al. 2019). Also, many of the studies investigating the long-term effects of breastfeeding have focused on chronic and non-communicable diseases like obesity, diabetes, cancer, and cardiovascular diseases in later years (Lodge et al., 2015; Izadi et al., 2013; Horta et al., 2007; Kwan et al., 2004; Leeson et al., 2001).

Except for a few studies (Pattison et al., 2019; Frank et al., 2019; Yamakawa et al., 2015), research on the long-term benefits of breastfeeding on acute illnesses in early childhood is lacking (Horta, 2019). Overall, the literature on IYCF practices indicates that research on the long-term impact of breastfeeding on acute child health outcomes is scarce, especially in developing countries. More importantly, to the best of my knowledge, no research has explored the long-term benefits of any breastfeeding duration on acute child health outcomes after infancy in sub-Saharan Africa.

This study uses data from the Nigerian Demographic and Health Survey (NDHS) to explore the long-term benefit of any breastfeeding duration on acute health outcomes in childhood. It specifically examines the impact of five different categories of any breastfeeding duration on child health outcomes after breastfeeding has stopped. Nigeria is uniquely suited as a case study for the sub-Saharan region because not only does it account for the highest under-five mortality rates in the region, but it also shares similar cultural, socio-economic, political, and demographic characteristics with many countries in the region. I expect that children who are breastfed longer would have fewer incidents of acute illnesses post-infancy, long after breastfeeding has stopped.

Breastfeeding and Acute Health Outcomes in Childhood

Acute health conditions like respiratory infections, diarrhea, pneumonia, sinusitis, throat infections, and malaria are principal causes of childhood morbidity and mortality particularly in LMICs (Ugboko et al., 2020; Troeger et al., 2017; Gupta G. R, 2012). In 2020, the top 10 countries with the highest mortality rates for children under five were LMICs. Five of these countries were in sub-Saharan Africa (UNICEF, 2020). A large body of literature documents the positive impacts of breastfeeding on health outcomes, yet no research assessing the long-term benefits of breastfeeding has been conducted in sub-Saharan Africa. Further, few studies in this region have investigated the relationship between breastfeeding duration and acute illnesses in later childhood. Studies done in sub-Saharan Africa focus more on breastfeeding practices and breastfeeding determinants; with few analyzing the impact of breastfeeding or its duration on childhood health outcomes (Anin et al, 2020; Agho et al, 2019; Ogbo et al., 2017).

The impact of breastfeeding on acute childhood illnesses like otitis media, respiratory infections, sinus infections, throat infections, and general hospitalizations among children has been extensively studied in developing countries with most indicating positive associations. Duncan et al. (1993) using data from 1220 infants enrolled in the Tucson Children's Respiratory Study found that exclusive breastfeeding for four or more months was protective from single and recurrent episodes of otitis media. Another study by Dewey et al. (1995) using a birth cohort of 92 infants found that compared to formula-fed infants, being breastfed was associated with a reduction in childhood morbidities like diarrhea, otitis media, and upper respiratory illnesses.

Research on the relationship between breastfeeding and acute child health outcomes has shown some variations in methodology and findings. Quigley et al. (2007) used data from a population-based survey of 15,890 infants born between 2000-2002 in the United Kingdom. Their result suggests that compared with no breastfeeding, exclusive breastfeeding is protective

against hospitalizations for both diarrhea and lower respiratory tract infection. Yamakawa et al. (2015) using longitudinal data (n=43,367) obtained from a national survey of Japanese children, explored the effects of breastfeeding on respiratory tract infections and diarrhea in early childhood. Their results demonstrate the long-term protective effects of breastfeeding on hospitalization for respiratory tract infections beyond infancy. However, this was not the case for diarrhea. The difference in diarrhea outcomes between the two studies above may likely result from the different methodologies employed. The previous study examined the short-term relationship while the latter looked at the long-term or temporal effects of breastfeeding on diarrhea incidents.

There are some inconsistencies in the research on respiratory and gastrointestinal infections; it is unclear if only exclusive breastfeeding is protective or "any breastfeeding" at all offers protection (Lamberti et al., 2011). However, exclusive breastfeeding has been generally associated with fewer episodes of infection in infants (Frank et al., 2019; Tiewsoh et al., 2009; Li et al., 2014;). Lamberti et al. (2011) did a random-effects meta-analysis of eighteen studies on breastfeeding from developing countries. Their findings indicate that varying degrees of protection against ARI and diarrhea result from exclusive breastfeeding and non-exclusive breastfeeding among infants and young children less than 23 months old. Etiler and colleagues (2002), examined factors associated with ARI in infancy. Their studies show that compared to exclusive breastfeeding, non-exclusive breastfeeding within the first four months of life is correlated with higher incidents of ARI. Raisler et al. (1999) examined the relationship between breastfeeding doses and acute health outcomes in infants using data from the National Maternal and Infant Health Survey. Their results suggest that exclusive breastfeeding is associated with

lower rates of ARI, diarrhea, and vomiting among infants compared to non-exclusive breastfeeding.

Breastfeeding Research in LMICs

There has been relatively less research on the relationship between breastfeeding and childhood illnesses in LMICs. Findings from these countries appear to be similar across with some variations in specific outcomes. Using data from a cohort of 1,731 infants enrolled near birth and followed for two years, Richard et al. (2018) examined the relationship between exclusive breastfeeding and child health outcomes in 8 low-income countries. Their results demonstrate the protective effect of exclusive breastfeeding in early childhood on common illnesses like diarrhea and acute lower respiratory infections. Using cross-sectional data (n=6,068) on mother-child pairs in different regions of Vietnam, Hejeebhoy et al. (2014) examined the associations between breastfeeding practices and infant illnesses. Their results indicate that breastfeeding has a positive effect on health and nutritional outcomes in children.

Ahmed et al. (2020) using cross-sectional data from the Ethiopian Demographic and Health (EDHS) data, explored the associations between Infant and Young Child Feeding (IYCF) practices and child health outcomes in Ethiopia. Their results indicate that children exposed to Early Infant Breastfeeding (EIBF) had a lower prevalence of ARI. Additionally, compared to no breastfeeding, supplementary breastfeeding at 0-5 months was associated with a lower prevalence of diarrhea. Another study by Berde et al. (2016) using the 2013 NDHS discusses how suboptimal breastfeeding practices across the geopolitical zones in Nigeria, contribute largely to diarrhea mortality and disability in children under five years. However, a regional analysis of associations between IYCF practices and diarrhea in India indicates that though EIBF

and exclusive breastfeeding were protective against the disease, supplementary breastfeeding at two years was associated with higher incidents of diarrhea (Dhami et al, 2020).

Overall, the literature reveals that comparatively fewer studies from developing countries have explored the immediate and long-term impacts of breastfeeding on child health outcomes. In sub-Saharan Africa, breastfeeding studies have focused more on the determinants of IYCF practices (Yalçin S.S, 2016; Issaka A. I, 2017; Woldeamanuel, 2020). Ogbo et al. (2015) investigated the determinants of suboptimal breastfeeding attitudes and practices using the 2008 Nigeria Demographic and Health Survey (NDHS) data. Their results indicate that bottle-feeding was more prevalent among educated mothers and wealthier households. Research by Agho et al. (2019) indicates that older mothers (35-49 years), mothers with primary education, living in rural communities, and mothers who made >= 4 prenatal care appointments were significantly more likely to engage in exclusive breastfeeding.

Breastfeeding Duration and Child Health Outcomes

World Health Organization (WHO) recommendations encourage exclusive breastfeeding of infants for 6 months and supplementary breastfeeding for up to 2 years (Benova et al, 2020). In line with this recommendation, many studies in developing countries have examined the effect of various breastfeeding durations on child health outcomes. Pattison et al. (2019) using data from the longitudinal perspective baby study in the United States investigated the relationship between breastfeeding duration and acute and chronic diseases at 6 to 36 months of age. Their results suggest that longer durations of breastfeeding are associated with fewer cases of diarrhea and constipation at 6, 12, and 24 months. Chantry et al. (2006) using data from the National Health and Nutrition Examination Survey III in the United States found that exclusive breastfeeding for 6 months compared to four months provides more protection against

gastrointestinal infection, but not respiratory tract infection. In contrast, a population-based prospective cohort study by Duijts et al. (2010), explored the associations of different durations of exclusive breastfeeding with upper and lower respiratory tract infections and gastrointestinal tract infections in infancy. Their study indicates that breastfeeding for four months and greater reduced respiratory and gastrointestinal illnesses in infants.

A good number of studies have used exclusive breastfeeding to examine the impact of breastfeeding duration on child health outcomes. However, some studies have used partially breastfed infants for their analysis. For example, Lopez-Alarcon et al. (1997) used data on both fully and partially breastfed infants in a birth cohort of 170 healthy newborns. Their results show that in both partially and fully breastfed infants, lower prevalence and shorter episodes of ARI and diarrhea were associated with longer breastfeeding duration in infants under 6 months of age. In another study, Hatakka et al. (2010) using a sample of 594 partially breastfed children examined factors associated with acute respiratory illnesses in children attending a daycare facility. Their results indicate that partial breastfeeding for greater or equal to six months was associated with reduced episodes of acute otitis media. The protective effect of breastfeeding duration beyond infancy has also been investigated with varying inferences. Frank et al. (2019) using data from a longitudinal study found that longer durations of exclusive breastfeeding in infancy were associated with higher incidents of common cold at 48 months of age even though it was inversely associated with the odds of otitis media. Gerhart et al. (2018) found that shorter durations of exclusive breastfeeding in infancy were associated with recurrent cough in adulthood.

Except for a few studies (Pattison et al., 2019; Frank et al., 2019; Yamakawa et al., 2015) research on the temporal benefits of breastfeeding duration on communicable illnesses in early

childhood is scarce. Investigations into the impact of breastfeeding duration on health outcomes in childhood have focused on the immediate effects in infancy or the first 12 months of life (Etiler et al., 2002; Ladomenou et al., 2010). Furthermore, studies on the long-term benefits of breastfeeding duration have focused more on chronic and non-communicable diseases like obesity, diabetes, cancer, and cardiovascular diseases in later years (Lodge et al., 2015; Izadi et al., 2013; Horta et al., 2007; Kwan et al., 2004; Leeson et al., 2001). For example, a systematic review and meta-analysis by Lodge et al. (2015) demonstrates the long-term benefit of breastfeeding in preventing asthma and allergies in later years (5 to 18 years). Similarly, an examination of the long-term effects of breastfeeding by Horta et al. (2007) demonstrates the efficacy of breastfeeding duration in reducing blood cholesterol, blood pressure, and type 2 diabetes in adulthood. More research is needed to understand the long-term impact of breastfeeding duration on acute health outcomes in early childhood, particularly the years following infancy.

Few studies on breastfeeding from LMICs; particularly in sub-Saharan Africa have measured the impact of breastfeeding duration on acute child health outcomes. A study carried out by Nigatu et al. (2019) examined the short-term impact of exclusive breastfeeding duration on childhood illnesses and nutritional outcomes in Ethiopia using the EDHS Data. Their results indicate that higher breastfeeding durations were correlated with lower rates of ARIs, diarrhea, child wasting, and undernutrition. Similarly, in a cohort study conducted by Mihrshahi et al. (2008), higher durations of exclusive breastfeeding were associated with lower rates of diarrhea and acute respiratory infections in infancy in Bangladesh. These studies, however, did not investigate the temporal impact of these durations of breastfeeding on these health outcomes in later childhood.

Against this backdrop of extensive literature review, WHO recommendations, and the need to provide more evidence on the efficacy of breastfeeding in reducing morbidities in vulnerable populations of children living in a region relatively less studied, I explore the following hypothesis:

H1: Children breastfed for longer durations have fewer recent incidents of acute illnesses post infancy; long after breastfeeding has stopped.

Research Design

Data and Sample

This study uses the 2008 NDHS which contains information on breastfeeding practices, breastfeeding duration, and health indicators for child health for all children surveyed. The Demographic and Health Surveys are nationally representative surveys that are conducted in many low and middle-income countries in collaboration with the United States Agency for International Development (USAID). They are also considered to be the best available health data from developing countries where comprehensive health data is otherwise absent.

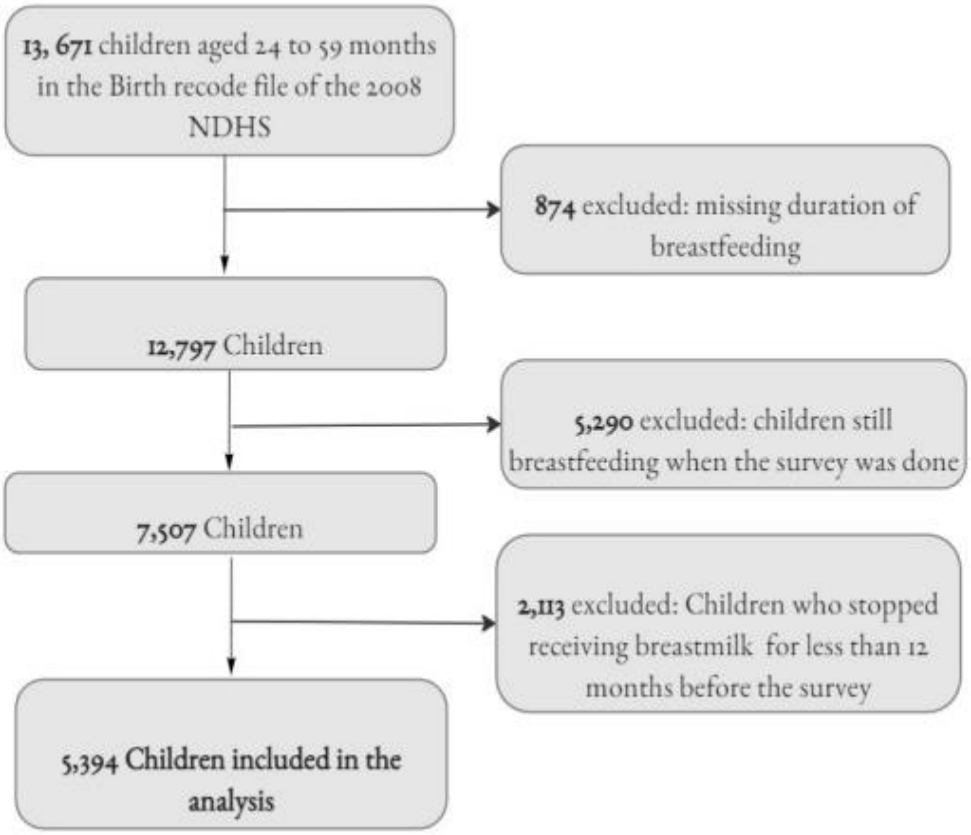
The NDHS survey provides cross-sectional data on the demographics, socioeconomic characteristics, nutrition, and health indicator estimates of the population in Nigeria. Data are obtained from randomly selected households across the six geopolitical zones in the country. The 2008 NDHS applied a stratified two-stage cluster design consisting of 888 clusters to select study participants from a complete listing of households and a mapping exercise carried out for each cluster from April to May 2008. More information on the sampling design, sampling technique, and sample size determination are available in the 2008 DHS county report2.

[2] https://dhsprogram.com/pubs/pdf/fr222/fr222.pdf

The 2008 NDHS data set is the most recent survey data with information on breastfeeding duration for every child present in each household included in the survey. After 2008 and for surveys based on the DHS-VI or DHS-7, information on the duration of breastfeeding and acute health outcomes is only collected only for the youngest children or those who are still breastfeeding at the time of the survey3. The Women's questionnaire used in the survey collects data on breastfeeding and recent incidents of acute health outcomes in children. Information on breastfeeding duration, recent incidents of fever, cough, running nose, short and rapid breaths, and diarrhea in children are based on the mother's recall. A total of 5,394 children aged 24 to 59 months whose mothers had stopped breastfeeding for at least twelve months were used in this study. Figure 1a shows the inclusion and exclusion criteria applied in the selection of the sample used for the analysis

[3] https://dhsprogram.com/data/Guide-to-DHS-Statistics/Breastfeeding_and_Complementary_Feeding.html

Figure 1a: Inclusion and exclusion criteria for the sample selection



Outcome variable measurement

The outcome variable in this study is any recent incident of acute health outcomes in children. Specifically, diarrhea and acute respiratory illness (ARI) in the two weeks preceding the survey. These outcomes were operationalized from yes or no (0/1) answers to the following questions in the survey questionnaire; a) has the child had diarrhea in the last 2 weeks? b) has the child been ill with a fever at any time in the last 2 weeks? c) has the child had an illness with a cough at any time in the last 2 weeks? d) when the child has an illness with a cough, did he/she breathe faster than usual with short, rapid breaths or have difficulty breathing in the last 2 weeks? A recent incident of diarrhea in a child was coded as 1 if a child's mother's response to

the diarrhea question (a) was “yes”. A recent incident of ARI in a child was recorded and coded as 1 if a child’s mother’s response to questions (b), (c), and (d) was “yes” (Nigatu et al., 2019).

Exposure variable measurement

According to WHO recommendations, ‘any breastfeeding’ includes exclusive, predominant, partial, or full breastfeeding (WHO, 2009). The main exposure variable in this study is the duration of “any breastfeeding”. This was grouped into 5 categories; 0-6 months, 7-12 months, 13-18 months, 18-24 months, and >24 months (Wong et al., 2018; Chowdhury et al., 2015).

Covariates

Covariates include the mother’s age, child’s age, mother's education (Lambert et al., 2011), gender of the child (male or female), mother's employment status, place of residence (urban or rural), availability of improved water and sanitation facilities -WaSH (Nigatu et al.,2019) and mother's marital status (Frank et al., 2019; Pattison et al., 2019). Nigeria has 6 geopolitical zones (North-east, North-west, North-central, South-east, South-west, and South-south). I also control for the region of the country the child resides in (See Table 1a).

Data Analysis

Logistic regression models were to examine the long-term effect of the five categories of breastfeeding duration on acute child health outcomes in children aged 24 to 59 months (Nigatu et al., 2019).

I estimate crude (equation 1) and adjusted (equation 1) odds ratios using the models described below:

$$Pr\ (Ych_i=1)) = \beta_0 + \beta_1 bfeeddur_t \quad (1)$$

$$Pr\ (Ych_i=1)) = \beta_0 + \beta_1 bfeeddur_t + \beta_2 motherage_i + \beta_3 childage_i + \beta_4 educ_i + \beta_5 male_i + \beta_6 employ_i + \beta_7 urban_i + \beta_8 WASH_i + \beta_9 married_i + \beta_{10} geogreg_x \quad (2)$$

Y_{ch} is a dichotomous variable (0/1) that equals 1 if the child had a recent incident of either diarrhea or ARI and 0 if otherwise. $Bfeeddur_t$ is a vector for breastfeeding duration with *t* capturing the different categories of breastfeeding. 0-6 months was used as the baseline category in the analysis. Other covariates include $motherage_i$, $childage_i$, $educ_i$, $gender_i$, $employ_i$, $urban_i$, *married*, $WASH_i$, and $geogreg_x$ which respectively capture a child's mother's age (years), child's age (months), a child's mother's educational level (0/1 dichotomous variable for college education), gender of the child (0/1 dichotomous variable for male), a child's place of residence (0/1 dichotomous variable for urban), a child's mother's marital status (0/1 dichotomous variable for married), a child's mother's employment status (0/1 dichotomous variable for employed), the availability of water and sanitation facilities- WaSH in a child's household (0/1 dichotomous variable) and geographical region of the country a child resides in (vector for the different regions of the country as described in Table 1a; Northeast was used as the baseline category). R statistical package was used for the analysis and all statistical significance was determined at a p-value of less than 0.05.

Results

Descriptive Statistics

A total of 5394 children aged 24-59 months whose mothers had stopped breastfeeding for at least 12 months were included in the analysis. The mean maternal age in the sample was 31.6 (SD=7.1) years. About 16.8% of the children were in the age range of 24 to 35 months while those aged 36 to 59 months made up about 83.2% of the sample. Ninety-two percent of the mothers in the sample did not have a higher education (post-secondary school education) and thirty percent were unemployed. Over sixty-seven percent of children in the sample lived in urban areas and male children made up about fifty-five percent of the sample. Other information on the household and geographical residence of the child is highlighted in Table 1a.

Table 1a: Sociodemographic characteristics of mothers, children, and household facilities, 2008 NDHS

Variables (N=5394)	Frequency (% and mean)
Age of child in months	
24 to <36	904 (16.8)
36 to <48	2180 (40.4)
48 to 59	2310 (42.8)
Maternal age	31.57 (SD=7.1)
Maternal education	
Others (No education, Primary and Secondary)	4964 (92.0)
Higher	430 (8.0)
Maternal employment	
Unemployed	1619 (30.2)
Employed	3775 (69.8)
Place of residence	
Urban	3644 (67.6)
Rural	1750 (32.4)
Sex of child	
Male	2775 (51.5)
Female	2619 (48.5)

Table 1: Contd.	
Toilet facility	
Improved toilet	2797 (51.9)
Unimproved toilet	2597 (48.1)
Source of drinking water	
Improved source of water	3018 (56.0)
Unimproved source of water	2376 (44.0)
Disposal of child's stools when not using a toilet	
Properly disposed	3235 (60.0)
Not properly disposed	2160 (40.0)
The geographic location of household	
North-central	1026 (19.0)
North-east	951 (17.6)
North-west	1234 (22.9)
South-east	268 (10.5)
South-south	770 (14.3)
South-west	845 (15.7)

Breastfeeding duration and recent incidents of acute health outcomes in children

Almost 20 percent of children in the sample were breastfed for either 0-6 months or 7- 12 months. Those who were breastfed for longer durations made up about 80% of the total sample. For recent incidents of acute health outcomes, about 7 percent of the children had diarrhea and about 3% percent had ARI (Table 1b).

Table 1b: Breastfeeding durations and acute health status of children ages 24-59 months, 2008 NDHS

Variables (N=5394)	**Frequency (%)**
Any breastfeeding	
0 - 6 months	143 (2.7)
7 - 12 months	961 (17.8)
13 - 18 months	2269 (42.1)
19 - 24 months	1928 (35.7)
>24 months	93 (1.7)

Diarrhea in the last 2 weeks	
Yes	368 (6.8)
No	5002 (92.7)
Acute respiratory Illness in the last two weeks	
Yes	154 (3.4)
No	4387 (96.6)

Effect of breastfeeding duration on recent incidents of acute health outcomes in Children

The results indicate that longer durations of breastfeeding are associated with lower odds of recent incidents of ARI. Tables 1c and 1d report the Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) respectively. Compared to children breastfed for 0-6 months, children breastfed for 7-12 months had lower odds ARI (AOR = 0.38, p-value = 0.02) at 24-59 months of age. Similarly, children breastfed for 13-18 months duration had lower odds of ARI (AOR = 0.41, p-value = 0.03), and children breastfed for 19-24 months duration had lower odds of ARI (AOR = 0.37, p-value = 0.02). The findings for diarrhea are mixed. In the unadjusted model, children breastfed for 19-24 months duration had higher odds of diarrhea (COR = 3.03, p-value = 0.02). However, the effect size attenuates and the relationship becomes insignificant in the AOR.

The results for all the sociodemographic, household, and regional variables included in the second logit model (equation 2) are shown in Table 1d. The findings suggest that being married, educated, and living in an urban area is associated with lower odds of recent incidents of ARI and diarrhea. An additional year in a child's age is also associated with lower odds of these acute health outcomes. Being male, however, is associated with higher odds of the investigated acute health outcomes. These results are, however, only statistically significant in the diarrhea model. Finally, compared to the Northeastern region of the country, being from any other region of the country is associated with lower odds of recent incidents of these acute health outcomes.

Table 1c: Effect of any breastfeeding duration on recent incidents of acute respiratory infection or diarrhea among children aged 24-59 months in Nigeria (Crude Odds Ratios)

Any breastfeeding duration	**Acute health outcomes**	
(baseline = 0-6 months)	*ARI*	*Diarrhea*
7 - 12 months	0.38** [0.17-0.87]	1.11 [0.43-2.86]
13 - 18 months	0.46** [0.22-0.98]	1.55 [0.62-3.86]
19 - 24 months	0.51* [0.24-1.09]	3.03** [1.23-7.49]
>24 months	0.35 [0.07-1.70]	1.84 [0.54-6.24]

*** significant at p-value less than 0.05; * significant at p-value less than 0.10*

Table 1d: Effect of any breastfeeding duration on recent incidents of acute respiratory infection or diarrhea among children aged 24-59 months in Nigeria (Adjusted Odds Ratio)

Variables	***Acute health outcomes (Adjusted Odds Ratio - AOR)***	
Any breastfeeding (baseline = 0-6 months)	ARI	Diarrhea
7 - 12 months	0.37** [0.16-0.86]	0.99 [0.38-2.61]
13 - 18 months	0.39** [0.18-0.86]	1.21 [0.48-3.05]
19 - 24 months	0.35** [0.15-0.79]	1.81 [0.62-3.92]
>24 months	0.32 [0.06 -1.50]	1.48 [0.42-5.21]
Married	0.87 [0.48-1.58]	0.58*** [0.38-0.88]
Mother's age	0.99 [0.97-1.02]	1.00 [0.99-1.02]
Child's age	0.99 [0.97-1.01]	0.97*** [0.96-0.98]
Education (Baseline= less than higher education)		
Higher education	0.64 [0.28-1.42]	0.75 [0.42-1.33]
gender (Baseline= male)		
Male	1.06 [0.77-1.47]	1.52*** [1.22-1.90]

Employment status (Baseline= unemployed)		
Employed	1.19 [0.83-1.73]	1.16 [0.91-1.47]
Place of residence (Baseline= rural) *Urban*	0.97 [0.65-1.44]	0.87 [0.66-1.15]
WASH	1.05 [0.70-1.58]	0.94 [0.70-1.25]
Geopolitical region (Baseline=North-east) *North-west*	0.43*** [0.12-0.68]	0.55*** [0.41-0.72]
North-central	0.29*** [0.17-0.50]	0.23*** [0.16-0.34]
South-west	0.07*** [0.02-0.20]	0.27*** [0.17-0.41]
South-east	0.56* [0.32-1.00]	0.33*** [0.21-0.52]
South-south	0.45*** [0.26-0.78]	0.22*** [0.14-0.35]

*Note: *** significant at p-value less than 0.01; * significant at p-value less than 0.10*

Sensitivity analysis

In the first sensitivity analysis, a sample of children whose mothers had stopped breastfeeding for at least 6 months was used. In the second sensitivity analysis, the complete sample of children aged 24-59 months no longer breastfeeding without considering the number of months since breastfeeding cessation was analyzed. The results (See Appendix 1 and 2) from both sensitivity analyses are still very similar to Tables 1c and 1d. The odds of recent incidents of ARI in children breastfed for longer than 0-6-month duration were significantly lower in both analyses.

Discussion

Despite the large body of research on the efficacy of longer breastfeeding durations in improving health outcomes during infancy, there is still a paucity of research on its long-term impact on acute health outcomes after infancy. This study examined the association between any breastfeeding duration and recent incidents of acute health outcomes in young children after they had stopped receiving breastmilk. A key finding from this study is the relationship between breastfeeding duration and acute health outcomes post-infancy. Overall, the results support the hypothesis that longer durations of "any breastfeeding" are associated with fewer incidents of ARI among children 24 to 59 months of age.

Children who were breastfed for more than the 0-6-month duration had lower odds of recent ARI post-infancy and long after breastfeeding had stopped. Though the crude odds ratio for the diarrhea model suggests that a longer duration of breastfeeding is associated with higher reported cases of diarrhea in children, the results are not statistically significant in the adjusted odds ratio; suggesting that breastfeeding duration greater than 6 months was not associated with recent episodes of diarrhea among children 24-59 months of age.

This study adds to the breastfeeding literature by examining the long-term impact of breastfeeding durations on acute health outcomes after infancy. Furthermore, I use data from a region where there is a paucity of research on the relationship between breastfeeding and health outcomes after infancy was utilized for the analysis. The findings from this study are consistent with previous studies that demonstrate the efficacy of longer durations of breastfeeding in reducing morbidity in infants (Duijts et al., Pattison et al., 2019; Horta et al., 2007; Wong et al., 2018). Specifically, the study provides evidence that confirms that longer durations of "any breastfeeding" are associated with reduced odds of recent ARIs in children months after breastfeeding has stopped. Similar to this study, a study by Li et al. (2014) demonstrates the

efficacy of longer durations of exclusive breastfeeding in reducing ARIs post-infancy. The study found that longer durations of breastfeeding protect against respiratory infections at 6 years old. Other studies also show evidence of the positive effects of longer breastfeeding durations in reducing respiratory tract illnesses in infants and young adults (Chantry et al, 2006; Tromp et al., 2017; Christensen et al., 2020).

This study provides no evidence that longer durations of breastfeeding reduce incidents of childhood diarrhea. The crude odds ratio shows a positive relationship between a longer duration of "any breastfeeding" and recent incidents of diarrhea in children. However, the adjusted odds ratio for diarrhea in this study shows no statistical significance. Past research on the efficacy of breastfeeding in reducing the incidents of diarrhea in children reports mixed results. A similar study to this study, conducted in sub-Saharan Africa reports a positive and statistically significant relationship between longer breastfeeding durations and reported cases of diarrhea in children (Ogbo et al., 2017). Another study in India reports that supplementary breastfeeding at two years was associated with higher incidents of diarrhea (Dhami et al, 2020). However, most studies have reported that longer breastfeeding times reduce the incidents of acute diarrhea in infants and children (Santos et al., 2015; Lamberti et al., 2011).

The results in Table 1d are also consistent with previous research which shows that child health outcomes are associated with maternal and child sociodemographic characteristics like a child's mother's marital status, level of education age, and type of residence a child resides (Ullah et al., 2019; Siziya et al., 2009; El Gilany et al., 2005). The odds of recent episodes of diarrhea were lower in children who were older and whose mothers were married. Furthermore, this study provides evidence of regional differences in the odds of recent episodes of ARIs and diarrhea in children. Compared to the children living in the northeastern region of the country;

which makes up about 17% of the total sample of children in this study, children residing in other regions had lower odds of both ARIs and diarrhea.

Overall, this study supports current literature describing the long-term positive effects of longer breastfeeding times on health outcomes. Despite significant improvements since 1990, Nigeria still accounts for one of the highest under-five deaths in sub-Saharan Africa, and ARI is a significant contributor to this burden (Sharrow et al., 2022). This study suggests that increasing the duration of any breastfeeding beyond 0-6 months has a significant impact in reducing incidents of ARIs in later childhood. Furthermore, it provides support for the WHO recommendation that breastfeeding should continue as a supplement for up to 2 years. Based on these findings, I recommend "any breastfeeding" for up to 24 months as this has the potential to reduce the incidents of respiratory illnesses even after breastfeeding has stopped.

This study has several unique strengths. The NDHS is a large survey and is considered to be the best available health data from developing countries where comprehensive health data is otherwise absent. In addition, this study controlled for several potential confounding factors including some not considered in past research on breastfeeding. Potential confounders such as household water and sanitation facilities, as well as regional effects, have not been considered in many past studies; especially those conducted in sub-Saharan Africa. Another strength of the study is the use of nationally representative data which improves the external validity of the findings to Nigeria specifically. Furthermore, the study design reduces the potential for reverse causality and temporal ambiguity common in many observational studies like this (Hammerton and Munafo, 2021). The study design employed was able to establish temporal relationships and thus can infer the direction of the associations.

This study has several limitations. The main limitation is the use of observational data that cannot fully account for differences in socio-demographic, physiological, and behavioral factors between study participants (Pattison et al., 2019). Though we attempted to adjust for potential confounding variables in the statistical analysis, differences among study participants likely remain and would impact the findings. It is also important to acknowledge that this study did not differentiate between exclusive and non-exclusive breastfeeding. The use of "any breastfeeding" duration may potentially reduce the true effect of breastfeeding and bias the results toward the null hypothesis (Ip et al., 2007; Pattinson et al., 2019). Lastly, the study did not consider other nutritional factors like the types of meals children in the sample consumed in the weeks before the survey. This could potentially bias the findings of this study towards or away from the null hypothesis. I also acknowledge that the data set used in this study is not very recent; over 10 years old. However, this should not affect the validity of the findings as the objective of the study is to examine the biological role of breastfeeding durations on future health outcomes of children. Furthermore, some recent studies on the efficacy of breastfeeding on child health outcomes have used data from almost two decades (Oken et al., 2021; O'Connor, 2021; Brenoe et al., 2020; Yang et al., 2018).

Conclusion

This study provides further evidence of the relationship between breastfeeding duration and child health outcomes. Post infancy and after breastfeeding has stopped, children who received breastmilk for longer than 0-6 months duration had lower odds of ARIs. Regionally, sub-Saharan Africa has the highest under-five mortality rates in the world and ARI is a significant contributor to this burden. The data set used is from the most populous African country with geography, population, and diversity similar to many other countries in sub-Saharan

Africa. Thus, findings from this study also have broader potential health, economic, and social policy implications not just for Nigeria but also for this region of the world. Encouraging supplemental breastfeeding for a further 18 months after 6 months of exclusive breastfeeding; as recommended by the WHO could significantly reduce the incidents of ARIs and concurrently, under-five mortality rates in sub-Saharan Africa. This is even more pertinent for Nigeria which contributes the largest to child mortality rates in the region. Given that breastfeeding is highly accessible and also a low-cost preventative public health intervention, this recommendation is a worthwhile endeavor.

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CHAPTER 2: ENVIRONMENTAL FACTORS IN THE RELATIONSHIP BETWEEN INFANT FEEDING AND INFANT HEALTH OUTCOMES: THE ROLE OF LIVING ENVIRONMENTAL CONDITIONS

Introduction

Suboptimal living environmental conditions are still prevalent in many parts of sub-Saharan Africa. According to the UN World Water Development, only 24% of the population has access to safe drinking water (Behind, C.L.N.O, 2019; Eberhard, 2019). Furthermore, the quality of building materials used for walls, floors, and roofing in many households is inadequate or suboptimal; about 70% of households in the region lack at least one quality building material (WHO, 2021). The implication of this is that many infants and children are exposed to environmental pathogens responsible for acute health outcomes like diarrhea, malaria fever, flu, and ARI. Sub-Saharan Africa as a region currently records the highest under-five mortality in the world with diarrhea and Acute Respiratory Illnesses (ARIs) being significant contributors to this burden (WHO, 2020; Simen-Kapeu et al., 2021)

Many communicable diseases in infancy have been associated with the poor living environmental conditions that characterize slums and suboptimal housing in developing countries (Sheuya et al., 2007). Unimproved water, sanitation, and hygiene (WaSH) and housing, have been estimated to account for 25% of all preventable diseases; with diarrheal diseases and acute respiratory infections being the leading causes (Sheuya et al., 2007). Studies conducted in developing countries including sub-Saharan Africa have linked the quality of sanitation facilities and built living environments to diarrhea and ARIs (Nigatu et al., 2019; Aftab et al., 2022; Akinyemi & Morakinyo, 2018). Good sanitation which comprises the availability of improved toilets, water, and hygiene (WaSH) protects infants from enteric pathogens outside of their living environment (Baker et al., 2016; Brown et al., 2013). Similarly, walls, floors, and roofing

materials play an intermediating role in the exposure of infants to vectors or pathogens that predispose infants to acute health outcomes like malaria fever, ARIs, and pneumonia (Sikalima et al., 2021; Keleb et al., 2020; Yaya et al., 2018; Ippolito et al., 2017). Overall, poor sanitation and poorly built environments pose a particular risk for infants as they can easily become sources of bacterial and viral infections (Meek and Noble, 2022; Aftab et al., 2022; Akinyemi & Morakinyo, 2018; Brady, 2012).

Widely known for its rich content of nutrients, anti-microbial, anti-inflammatory, and immune factors, the protective benefits of breastfeeding against bacterial and viral infections have been extensively demonstrated (Nigatu et al., 2019; Santos et al., 2015; Quigley et al., 2007). Breastmilk is a well-recognized and uniquely suited infant nutrition and health intervention, especially in countries lacking extensive health infrastructure and where the alternative to breastmilk is less likely to be formula made with unsafe drinking water (Brenoe et al., 2022; Adeyinka et al., 2020; UNICEF, 2020; Roberts et al., 2013). While many countries in sub-Saharan Africa have recorded improvements in infant feeding and young child feeding practices over the decades, exclusive breastfeeding in the region is still below world health targets and is influenced by a complex set of socio-demographic and environmental factors (Berti & Socha, 2023; Jama et al., 2020; Khan et al., 2017; Gewa et al., 2015).

Nigeria is also uniquely suited as a case study for the sub-Saharan region because it shares similar cultural, socio-economic, political, and demographic characteristics with many countries in the region. Though Nigeria has recorded substantial reductions in infant mortality in recent years, it still accounts for the highest number of deaths from acute health outcomes in children under five years in the region (UNICEF, 2020). This study uses data from the Nigerian Demographic and Health Survey (NDHS) to examine the relationships between, exclusive

breastfeeding, household living environmental conditions of WaSH and built environment, and recent episodes of diarrhea and ARIs respectively. This data is used to explore the following broad research questions:

What aspects of an infant's household living environmental conditions are associated with exclusive breastfeeding? How do living environmental conditions interact with exclusive breastfeeding to impact acute child health outcomes (diarrhea and ARIs) during infancy? The answers to these questions have important implications for resources allocated to infant feeding promotion, infant nutrition, infant health, environmental sanitation, and housing programs.

Infant and Young Child Feeding, Living Environmental Conditions and Infant Health Outcomes

Promoting optimal infant and young child feeding practices (IYCF) and the improvement of living environmental conditions are two sides of the same strategic coin in the global effort to reduce infant morbidity and mortality (UNICEF, 2019; VanDerslice et al., 1994). These two strategies protect infants from infectious organisms in the environment through two mechanisms. First, due to its rich content in anti-microbial, anti-inflammatory, and immune factors, breast milk improves an infant's ability to resist infection (Nigatu et al., 2019; Santos et al., 2015; Quigley et al., 2007). Second, improved sanitary and built environmental conditions reduce infants' exposure to environmental pathogens (Mara et al., 2010; Sikalima et al., 2021; Keleb et al., 2020; Yaya et al., 2018; Ippolito et al., 2017; VanDerslice et al., 1994).

The type of infant feeding (exclusive or non-exclusive breastfeeding), sanitation, and built environment infants are exposed to impact their health outcomes. As stated earlier, breastmilk contains a rich amount of nutrients and immunogenic factors which improve an infant's ability to resist infection (Jackson & Nazar, 2006). Thus, compared to non-exclusive

breastfeeding, exclusive breastfeeding may provide greater protection to infants living in highly inadequate or suboptimal living environments. Also, because good water, sanitation, and hygiene (WaSH) and built living environments protect infants by reducing their exposure to pathogenic organisms or vectors that increase their risk for acute health outcomes, an adequate living environment may be most significant for infants not exclusively breastfed. When considered together, exclusive breastfeeding and improved living environmental conditions may form a set of sequential barriers that protect infants from pathogenic organisms that cause acute health outcomes in infancy.

Few studies have explored these gaps in the literature; most especially within the sub-Saharan African context. In a study using data collected from women in the Malaysian Family Life Survey, Habitch et al (1988) found that breastfeeding was associated with lower infant mortality and the effect was significantly stronger in households lacking toilet facilities or piped water. In a similar study using the same data, Butz et al (1984) assessed the impact of the duration of breastfeeding on infant mortality at various degrees of environmental sanitation. The study found that breastfeeding had the strongest effects when toilet and piped water were absent and relatively smaller effects in households where either of these facilities was present. The studies available are very old and consider only the WaSH facilities in the living environment of infants. However, the complete living environment should also consider the nature and quality of the building materials or built environment present in an infant's household (Gascon et al., 2016).

Available studies have also focused on enteric diseases caused by food or water-borne pathogens. No study has examined similar relationships for ARIs. Clemens et al (1990) examined the relationship between breastfeeding and the risk of cholera among Bangladeshi

children under 36 months of age. The protective effect of breastfeeding against an incident of cholera was strongest for children whose source of drinking water was open rivers compared to those with more improved drinking water sources. In a relatively more recent and similar study using data from Ghana and Nigeria, the protective effect of breastfeeding against diarrhea was greatest where the poorest sanitation facilities prevailed (Ahiadeke, 2000). A very recent study by Lubis et al (2021) examined the correlation between sanitation facilities and cases of diarrhea in breastfeeding toddlers in Indonesia. Their results suggest a relationship between the availability of basic sanitation facilities and a lower rate of diarrhea in breastfed infants.

The paucity of research in this domain is obvious and calls for more research investigating a broader scope of acute health outcomes in infancy as well as a broader aspect of a household's living environment. Furthermore, the nature of the interactions and relationships between environmental conditions and infant feeding is something that should be explored further. This is even more salient for a region of the world with a high prevalence of sub-optimal living environmental conditions as well as the highest under-five mortality rates globally.

It is against this background that this study uses data from the Nigerian Demographic and Health Survey (NDHS) to examine the relationship between, infant feeding (exclusive and non-exclusive breastfeeding), household living environmental conditions (WaSH and built environment), and recent episodes or incidents of diarrhea and ARIs. As stated earlier, the decision to exclusively breastfeed in many developing countries is influenced by a complex set of social and economic factors (Berti & Socha, 2023; Jama et al., 2020; Khan et al., 2017; Gewa et al., 2015). While these factors may be related to the physical environment, this component can be further decomposed to explore if the quality of WaSH facilities and building materials in a household is associated with the practice of exclusive breastfeeding. Furthermore, the constructs

within the Social Ecological Model were used to identify important mechanisms and concepts related to the objectives of the study.

I expect that there would be a relationship between exclusive breastfeeding and an infant's household living environment. I also expect a relationship between living environmental conditions (WaSH and building material quality) and acute health outcomes (diarrhea and ARI) in infants. Furthermore, improved or adequate living environmental conditions may be associated with better health outcomes in infants. Similarly, the combination of both exclusive breastfeeding and improved living environmental conditions (WaSH and building quality) may offer more protection against incidents of diarrhea and ARI in infants.

Lastly, there may be an interaction between exclusive breastfeeding and the living environmental conditions of WaSH and building quality in impacting associated acute health outcomes in children. Exclusive breastfeeding may provide greater protection against diarrhea for infants living in households with unsanitary conditions. Similarly, exclusive breastfeeding may provide greater protection against ARI for infants living in households with poor or inadequate building materials.

The hypotheses that are explored in this study flow from this conceptual framework:

Hypothesis 1: There is a relationship between living environmental conditions (WaSH and building materials quality) and exclusive breastfeeding.

Hypothesis 2a: Improved WaSH in a household is associated with lower odds of recent diarrhea in infants.

Hypothesis 2b: Improved building material in a household is associated with lower odds of recent ARI in infants.

Hypothesis 3a: A combination of exclusive breastfeeding and living in a household with improved WaSH is associated with fewer recent incidents of diarrhea in infants.

Hypothesis 3b: A combination of exclusive breastfeeding and living in a household with improved building materials is associated with fewer recent incidents of ARI in infants.

Hypothesis 4a: There is a significant interaction between exclusive breastfeeding and household WaSH in impacting recent incidents of diarrhea in infants.

Hypothesis 4b: There is a significant interaction between exclusive breastfeeding and the quality of household building materials in impacting recent incidents of ARI in infants.

Hypothesis 5a: Exclusive breastfeeding offers more protection against recent incidents of diarrhea for infants living in households where WaSH conditions are poor or inadequate.

Hypothesis 5b: Exclusive breastfeeding offers more protection against recent incidents of ARI for infants living in households where building materials are poor or inadequate.

Research Design

Data Collection and Sample

This paper uses pooled cross-sectional data from the Nigerian Demographic and Health Survey (NDHS) for the years 2008, 2013, and 2018. The Demographic and Health Surveys are nationally representative surveys conducted in many low and middle-income countries. They are funded by the United States Agency for International Development and are considered to be the best available health data from developing countries where comprehensive health data is otherwise absent.

The DHS survey uses a combination of women's and household questionnaires to collect both demographic, household, and health information from a sample of the population. The women's questionnaire collects data related to infant and young child feeding practices as well as

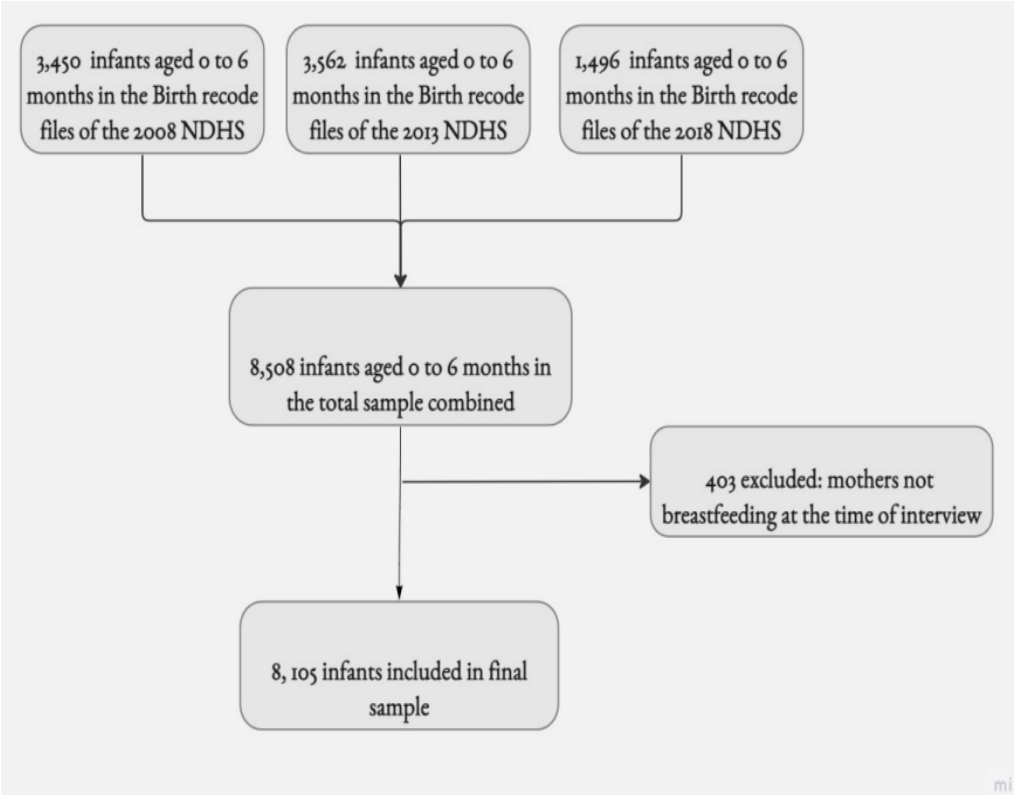
information on acute health outcomes in children. Information on the type of breastfeeding, recent incidents of fever, cough, running nose, short and rapid breaths, and diarrhea in children is based on the mother's recall. The household questionnaire collects basic information about the socio-economic characteristics of each household and data on the attributes of the household's living unit; including the water source, type of toilet facilities, and quality of building materials used for the floors, walls, and roofing.

The NDHS survey provides cross-sectional data on the demographics, socioeconomic characteristics, nutrition, and health indicator estimates of the population in Nigeria and data are obtained from randomly selected households across the six geopolitical zones in the country. The surveys for 2008, 2013, and 2018 NDHS applied a stratified two-stage cluster design. Each respective survey consisted of 888, 904, and 1400 clusters respectively to select study participants from a complete listing of households and a mapping exercise carried out for each cluster from April to May of each survey year.

More information on the sampling design, sampling technique, and sample size determination are available in 2008, 2013, and 2018 country DHS reports.[4] A total of 8,105 children aged 0 to 6 months whose mothers were still breastfeeding during 2008, 2013, and 2018 Nigerian Demographic and Health Surveys were included in the study. Figure 2a shows the inclusion and exclusion criteria applied in the selection of the sample used for the analysis.

[4] https://dhsprogram.com/pubs/pdf/fr222/fr222.pdf

Figure 2a: Inclusion and exclusion criteria used in the sample selection



Infant feeding practices

According to WHO recommendations, exclusive breastfeeding is breast milk from the mother, wet nurse, or expressed milk with no other liquids or solids except vitamin drops, supplements, or prescribed medicines (WHO, 2007). This study assessed feeding practices using a complete 24-hour dietary recall of infant feeding by mothers during each year's NDHS. A child was considered exclusively breastfed if their mothers gave them nothing else but breastmilk in the 24 hours before the interview (Nigatu et al., 2019; Khan & Islam, 2017; WHO, 2009). An infant was also classified as non-exclusively or partially breastfed if in addition to breast milk from the mother, wet nurse, or expressed milk, it also received other liquids or solids including both milk and non-milk products (Nigatu et al., 2019; WHO, 2007).

Infant health outcomes

The infant health outcomes examined in this study were diarrhea and acute respiratory illness (ARI). These outcomes were operationalized from yes or no (1/0) answers to questions to the following questions in the women's questionnaire.

a) has the child had diarrhea in the last 2 weeks?

b) has the child been ill with a fever at any time in the last 2 weeks?

c) has the child had an illness with a cough at any time in the last 2 weeks?

A recent incident of diarrhea in a child was coded as 1 if a child's mother's response to the diarrhea question (a) was "yes". A recent incident of ARI in a child was recorded and coded as 1 if a child's mother's response to questions (b), and (c) was "yes" (Nigatu et al., 2019).

Living environmental conditions

Infants included in the study sample were exposed to different living environmental conditions. To capture this complex array of both WaSH and built environment, the following living environmental factors were considered; drinking water source, toilet facilities, stool disposal practices (when the toilet is not in use), type of wall material, type of roofing material, and type of floor material present in the households.

These environmental factors were identified from answers to questions asked about a household's living unit in the household questionnaire of the NDHS. Using guidelines stipulated by the WHO and UNICEF Joint Monitoring Program (2017), the classification of the type of water and sanitation facilities in a household was done as described in Table 2a. The same guidelines were applied to categorize the type or quality of building materials present in the household at the time of the interviews (Table 2b).

Table 2a: Classification of improved sanitation, and water supply (WHO and UNICEF, 2017). Source: Yaya et al., 2018

	Unimproved	Improved
Toilet/hygiene (Sanitation)	An unimproved toilet does not ensure hygienic separation of human excreta from human contact. They include pit latrines without a slab or platform, hanging latrines, and bucket latrines. This also includes improper disposal of human stool when toilets are not in use; disposal of feces into drain or ditch, garbage or buried in the open.	An improved toilet ensures hygienic separation of human excreta from human contact. They comprise flush/pour-flush to a piped sewage system, septic tank, pit latrine; ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet. This also includes the proper disposal of human stool when toilets are not in use; the disposal of feces by burying it.
Water	Unimproved drinking water sources include unprotected springs, unprotected dug wells, carts with small tanks/drums, surface waters like rivers, dams, ponds, streams, canals, irrigation channels; and bottled water.	Improved water sources include standpipes, tube wells or boreholes, public taps, protected dug wells, protected springs, piped household water connection located in the user's household; piped water on premises, and rainwater

Table 2b: Classification of building materials for floors, walls, and roofs in the NDHS (Source: Yaya et al., 2018)

	Inadequate	Adequate
Floors	Materials made with earth, sand, mud, cardboard, wood plank, dung, and dirt.	Materials made of carpet, cement, ceramic tiles, parquet, polished wood, vinyl, and asphalt strips.
Wall	Materials made with earth, sand, mud, cardboard, wood plank, dirt, bamboo, no walls, uncovered adobe, palm, trunks, cane, and plywood.	Materials made out of cement, bricks, stone with lime, covered adobe, stone with mud, ceramic tiles, and cement blocks.
Roof	Made with cardboard, no roof, rustic mat, palm/bamboo, thatch/palm, sod, leaf, wood, and wood planks.	Made with calamine, ceramic tiles, cement, and metal.

Operationalization of household living conditions of WaSH and built environment

The mechanisms through which environmental conditions impact an infant's risk of acute health outcomes like diarrhea or ARI vary. The type of water and toilet, and stool disposal facilities when the toilet is not in use (hygiene), together capture the WaSH factors in a household and are measures of an infant's exposure to enteric pathogens that cause diarrhea and cholera (Mallick et al., 2020; Baker et al., 2016; Mengistie et al., 2013). Factors like the quality of walls, roofs, and floors present in a household capture the built environment and are measures of exposure to blood and respiratory pathogens that cause malaria fever, flu, pneumonia, and ARIs (Musiime et al., 2022; Aftab et al., 2022; Sikalima et al., 2021; Keleb et al., 2020). The operationalization of water and sanitation (WaSH) and built environmental factors present in a household are described in Table 2c.

The variable to capture poor WaSH (*pWaSH*) in a household was operationalized as the presence of unimproved WaSH facilities in a household (Table 2c). This was measured using the WHO's classification highlighted in Table 2a. The *pWaSH* variable was coded as 1 if all three facilities for WaSH were unimproved in a household; as shown in Table 2c. Similarly, the variable to capture poor built environment quality (*pbuilding*) in a household was operationalized and coded as 1 if the walls, floors, and roofing materials present in a household were all inadequate (Table 2c). This was measured using the WHO's classification highlighted in Table 2b.

Table 2c: Operationalization of the living environmental condition variables

Variable	**Environmental conditions**		
Poor water, sanitation, and hygiene in a household (*pWaSH*)	Unimproved toilet in a household (*ptoilet*)	Unimproved water source in the household (*pwater*)	Unimproved stool disposal in the household (*pstool*)
Poor building materials in a household (*pbuilding*)	Inadequate wall material in a household (*pwall*)	Inadequate floor material in a household (*pfloor*)	Inadequate roofing material in a household (*proof*)

Other risk factors (covariates)

Important demographic and socio-economic factors identified as potential confounders were also considered. These include a child's mother's age, a child's mother's education (Lambert et al., 2011), the gender of the child (male or female), the child's mother's employment status, the location of the child's household - urban or rural (Nigatu et al.,2019), the number of antenatal visits by the child's mother during pregnancy and the child's mother's marital status (Frank et al., 2019; Pattison et al., 2019). Time differences across the three years of data used in the study were also considered in the analysis.

Model Specification and Analysis

Multivariate models of acute illnesses in infancy typically include various risk factors in addition to infant feeding practice and household conditions of WaSH and built environment. These factors were considered in the models described below (Nigatu et al., 2019; Frank et al., 2019; Pattison et al., 2019).

To explore the first hypothesis examining the relationship between exclusive breastfeeding and living environmental conditions, two multivariate logit models were employed. The living environmental conditions variables included in the models are either a

single factor (equation 1) or a combination of variables that capture the overall quality of WaSH and the built environment in each infant's household (equation 2). These are described in equations 1 and 2.

$$Pr\ (Yexclus_i=1)) = \beta_0 + \beta_1 pwater_i + \beta_2\, ptoilet_i + \beta_3 pstool_i + \beta_4 pfloor_i + \beta_5 pwall_i + \beta_6 proof_i + \beta_7 motherage_i + \beta_8 childage_i + \beta_9 educ_i + \beta_{10} male_i + \beta_{11} employ_i + \beta_{12} urban_i + \beta_{13} married_i + ante_i + year_t \quad (1)$$

$$Pr\ (Yexclus_i=1)) = \beta_0 + \beta_2 pwash_i + \beta_3 pbuilding_i + \beta_4 childage_i + \beta_5 motherage_i + \beta_6 educ_i + \beta_7 male_i + \beta_8 employ_i + \beta_9 urban_i + + \beta_{10} married_i + ante_i + year_t \quad (2)$$

$Yexclus_i$ is a dichotomous variable (0/1) that equals 1 if the infant$_i$ was exclusively breastfed and 0 if non-exclusively breastfed. $pwater_i$, $ptoilet_i$, $pstool_i$, $pfloor_i$, $pwall_i$, and $proof_i$ in equation 1 are all dichotomous variables that equal 1 if the infant lives in a household with poor or unimproved water, poor toilet facilities, poor stool disposal when the toilet is not in use, poor or inadequate floor, inadequate walls, and inadequate roofing materials respectively. $pwash_i$ and $pbuilding_i$ in equation 2 are both dichotomous variables that equal 1 if the infant lives in a household with poor WaSH and inadequate building materials as described in Table 2c.

Other covariates $motherage_i$, $childage_i$, $educ_i$, $gender_i$, $employ_i$, $urban_i$, $married_i$, $ante_i$, and $year_t$ respectively capture the infant's mother's age (years), infant's age (months), infant's mother's educational level (0/1 dichotomous variable for college education), infant's mother's employment status (0/1 dichotomous variable for employed), infant's place of residence (0/1 dichotomous variable for urban), infant's mother's marital status (0/1 dichotomous variable for married), the number of antenatal visits by the infant's mother while pregnant (vector for the different levels of antenatal visits as described in Table 2f). (Frank et al., 2019; Pattison et al., 2019; Nigatu et al., 2019). Lastly, by controlling for year effects ($year_t$) the model also accounts for differences across the three years (2008, 2013, and 2018) of data used in the analysis.

To explore the second set of hypotheses examining the relationship between the living environmental conditions (WaSH and built environment) and acute health outcomes in infants, we also employ two multivariate logit models. These models are described in equations 3 and 4.

$$Pr\,(Ydiarh_i=1)) = \beta_0 + \beta_1 exclus_i + \beta_2 pwash_i + \beta_3 pbuilding_i + \beta_4 motherage_i + \beta_5 childage_i + \beta_6 childage_i^2 + \beta_7 educ_i + \beta_8 male_i + \beta_9 employ_i + \beta_{10} urban_i + + \beta_{11} married_i + ante_i + year_t \quad (3)$$

$$Pr\,(Yari_i=1)) = \beta_0 + \beta_1 exclus_i + \beta_2 pbuilding_i + \beta_3 pwash_i + \beta_4 motherage_i + \beta_5 childage_i + \beta_6 childage_i^2 + \beta_7 educ_i + \beta_8 male_i + \beta_9 employ_i + \beta_{10} urban_i + + \beta_{11} married_i + ante_i + year_t \quad (4)$$

$Ydiarh_i$ in equation 3 is a dichotomous variable (0/1) that equals 1 if, in the two weeks preceding the survey, the infant$_i$ had an incident of diarrhea and 0 if not. $Yari_i$ in equation 4 is another dichotomous variable (0/1) that equals 1 if the infant had an incident of ARI and 0 if not. $exclus_i$ in both equations is a dichotomous variable (0/1) that equals 1 if the infant was exclusively breastfed and 0 if non-exclusively breastfed. $pwash_i$ is a dichotomous variable (0/1) that equals 1 if the infant lives in a household with poor WaSH facilities (Table 2c) and 0 if otherwise. Similarly, $pbuilding_i$ is a dichotomous variable (0/1) that equals 1 if the infant lives in a household built with poor building materials (Table 2c) and 0 if otherwise. $childage_i^2$ is a quadratic term for the infant's age (VanDerslice et al., 1994). Other covariates remain as described in Equation 1.

To explore the third set of hypotheses examining the efficacy of both exclusive breastfeeding and the availability of improved living environmental conditions in offering increased protection against diarrhea and ARI for infants, two separate multivariate logit models described in equations 5 and 6 were utilized.

$$Pr\,(Ydiarh_i=1)) = \beta_0 + \beta_1 X_j + \beta_3 motherage_i + \beta_4 childage_i + \beta_5 childage_i^2 + \beta_6 educ_i + \beta_7 male_i + \beta_8 employ_i + \beta_9 urban_i + \beta_{10} married_i + \beta_{11} ante_i + \beta_{12} year_t \quad (5)$$

$$Pr\,(Yari_i=1)) = \beta_0 + \beta_1 Y_j + \beta_3 motherage_i + \beta_4 childage_i + \beta_5 childage_i^2 + \beta_6 educ_i + \beta_7 male_i + \beta_8 employ_i + \beta_9 urban_i + \beta_{10} married_i + ante_i + year_t \quad (6)$$

X_j in equation 5 is a vector for different combinations of types of infant feeding and household WaSH conditions described in Appendix 3. Similarly, Y_j in equation 6 is a vector for different combinations of infant feeding and built environment quality described in Appendix 4. The baseline category in equation 5 was the combination of exclusive breastfeeding and improved WaSH (double protection). The baseline category in equation 6 was the combination of exclusive breastfeeding and adequate building (double protection). All other variables in the model remain as described in equations 3 and 4.

To explore the fourth and the fifth set of hypotheses which explore how living environmental conditions interact with exclusive breastfeeding to impact incidents of diarrhea and ARIs in infancy, two separate multivariate logit models were employed again. Each model included an interaction between exclusive breastfeeding and an aspect of a household's living environment. In the model (equation 7) where diarrhea is the outcome, the interaction term includes exclusive breastfeeding and the poor WaSH variable - *pwash* (see Table 2c). In equation 8 where ARI is the outcome, the interaction term includes the poor built environment variable - *pbuilding* (see Table 2c). Each model also controls for the living environment variable not included in the interaction term to capture the full spectrum of factors that may, directly and indirectly, impact the health outcomes of infants (Nigatu et al., 2019; VanDerslice et al., 1994).

$$Pr\,(Ydiarh_i=1)) = \beta_0 + \beta_1 exclus_i + \beta_2\, pwash_i + \beta_3 exclus_i \times pwash_i + \beta_4 pbuilding_i + \beta_5 motherage_i + \beta_6 childage_i + \beta_7 childage_i^2 + \beta_8 educ_i + \beta_9 male_i + \beta_{10} employ_i + \beta_{11} urban_i + \beta_{12} married_i + ante_i + year_t \quad (7)$$

$$Pr\,(Yari_i=1)) = \beta_0 + \beta_1 exclus_i + \beta_1 pbuilding_i + \beta_3 exclus_i \times pbuilding_i + \beta_4 pwash_i + \beta_5 motherage_i + \beta_6 childage_i + \beta_7 childage_i^2 + \beta_8 educ_i + \beta_9 male_i + \beta_{10} employ_i + \beta_{11} urban_i + \beta_{12} married_i + ante_i + year_t \quad (8)$$

All the variables in the model remain as described in equations 3 and 4. β_3 is the coefficient of interest in both equations and it measures how much larger or smaller the relationship is between exclusive breastfeeding and the associated outcome for infants living in households with either poor WaSH or inadequate building materials. In equation 7 which is the diarrhea model, β_3 is the coefficient of interest for infants living in households with poor WaSH (*pwash*=1). In equation 8 which is the ARI model, β_3 is the coefficient of interest for infants living in households with poor or inadequate building material (*pbuilding*=1). Marginal effects analyses were conducted on the model outputs from equations 7 and 8 to further understand the interactions and explore the fifth hypothesis using the predicted probabilities of diarrhea and ARI under the different types of infant feeding and living environmental conditions.

Results

Descriptive Statistics

Infant Feeding and acute health outcomes (Diarrhea and ARI)

A total of 8105 infants aged 0-6 months whose mothers were still breastfeeding at the time of the interviews were included in the sample. The description type of infant feeding practice in the sample is shown in Table 2d. About 16% of infants in the sample were exclusively breastfed while 84% were non-exclusively breastfed. Also, the proportions of infants who experienced episodes of diarrhea and ARI in the two weeks preceding the interview were 8.1% and 5.4% respectively. Figures 2b and 2c suggest an inverse relationship between exclusive breastfeeding dose and acute health outcomes in the infants included in this study. Within a few weeks of birth (0 months), when the mean prevalence of exclusive breastfeeding was highest, there were fewer incidents of diarrhea and ARI as reported by their mothers in the sample. As the

mean prevalence of exclusive breastfeeding reduces with infant age, there is an associated increase in incidents of both diarrhea and ARI.

Table 2d: Breastfeeding and acute health status of infants (0-6 months) in the sample, 2008, 2013, and 2018 NDHS

Variables (N=8105).	**Frequency (%)**
Breastfeeding	
Exclusive breastfeeding	1316 (16.24)
Non-Exclusive breastfeeding	6789 (83.76)
Diarrhea in the last 2 weeks	
Yes	656 (8.11)
No	7431 (91.89)
Acute Respiratory Illness (ARI) in the last two weeks	
Yes	437 (5.40)
No	7652 (94.60)

Figure 2b: Exclusive breastfeeding and the prevalence of diarrhea by age (0-6 months) among the study infants

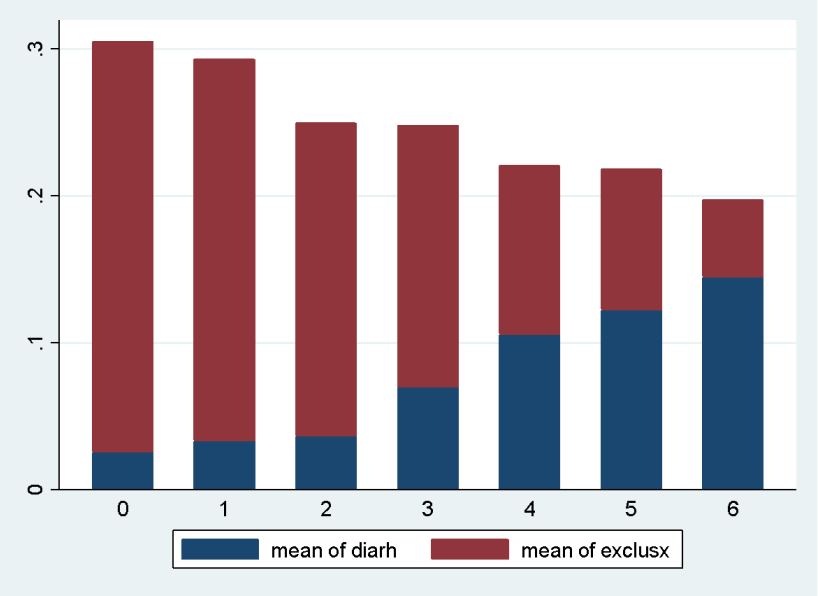
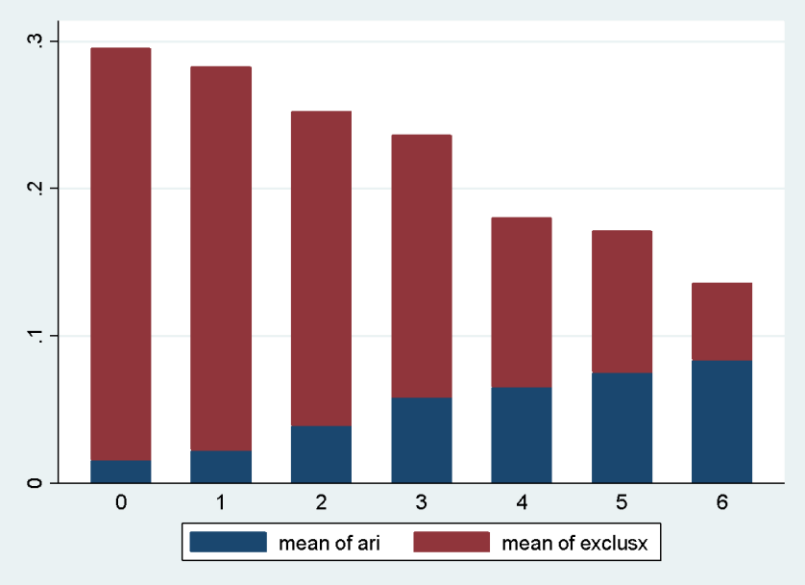


Figure 2c: Exclusive breastfeeding and the prevalence of ARI by age (0-6 months) among the study infants



Living environmental conditions

Table 2e indicates that at least one of the WaSH facilities of improved water, toilet, and proper stool disposal was available in many of the households included in this study. Households with improved toilet facilities made up approximately 48% of the sample. Similarly, households with an improved source of drinking water and proper disposal of stool when toilets were not in use made up about 52% and 50% of the sample respectively. Also, 70% of the sample had adequate roofing and 54% and 53% of the sample had adequate floors and walls respectively. However, all three of the WaSH facilities were completely absent in 10% of the household in the sample. Similarly, in 23% of the households, all three of the building materials were inadequate or poor.

Table 2e: Description of the living environmental conditions of households included in the sample

Variables	Frequency (%) and mean
Toilet facility	
Improved toilet	3885 (47.93)
Unimproved toilet	4220 (52.07)
Source of drinking water	
Improved source of water	4209 (51.93)
Unimproved source of water	3896 (48.07)
Disposal of child's stools when not using the toilet	
Properly disposed	3877 (49.51)
Not properly disposed	3954 (50.49)
Roof material	
Adequate	5706 (70.40)
Inadequate	2399 (29.60)
Floor material	
Adequate	4433 (54.69)
Inadequate	3672 (45.31)
Wall material	
Adequate	4328 (53.40)
Inadequate	3777 (46.60)
WaSH facilities (water, toilet, and stool disposal)	
Improved	7199 (89.91)
Unimproved	808 (10.09)
Quality of building environment (roof, floor, and wall materials)	
Adequate	6271 (77.37)
Inadequate	1834 (22.63)

Socio-demographic characteristics

Table 2f shows that with the exclusion of 0 months, the number of infants in each age category was for the most part equally split among the different age groups in the sample. The mean age of mothers in the sample is 27.71 (SD=6.02) years. Over 93% of the mothers in the sample did not have a higher education (post-secondary school) degree and about 39% percent of mothers were unemployed. Over sixty-eight percent of the infants in the sample lived in a household located in an urban area and the sample is almost equally distributed between male

and female infants. Information on the marital status of mothers and the number of antenatal visits by mothers is also provided in the table.

Table 2f: Descriptive statistics of infants and mothers in the sample, 2008, 2013, and 2018 NDHS

Variables	Frequency (%) and mean
Age of child in months	
0 months	714 (8.81)
1 month	1211 (14.93)
2 months	1160 (14.31)
3 months	1221 (15.06)
4 months	1292 (15.94)
5 months	1237 (15.26)
6 months	1271 (15.68)
Maternal age	27.71 (6.02)
Maternal education	
Others (No education, Primary and Secondary)	7597 (93.73)
Higher	508 (6.27)
Maternal employment	
Unemployed	3198 (39.65)
Employed	4868 (60.35)
Place of residence	
Urban	2534 (31.26)
Rural	5571 (68.74)
Sex of child	
Male	4061 (50.10)
Female	4044 (49.90)
Marital status	
unmarried	554 (6.84)
married	7550 (93.16)
Number of antenatal visits (average =4.6)	
0 visits	2648 (34.11)
0-3 visits	1970 (25.38)
> 4 visits	3145 (40.51)

Statistical Model Results

Infant feeding and living environmental conditions

The results in Tables 2g and 2h provide support for the first hypothesis. The results indicate that there is a statistically significant relationship between infant feeding practice and living environmental conditions. Table 2g highlights the results from the first model (equation 1) and indicates that infants living in households with inadequate roofs, floors, walls, and poor stool disposal practices were less likely to be exclusively breastfed by their mothers. Similarly, though not statistically significant, infants living in households with unimproved water facilities were less likely to be exclusively breastfed. However, mothers living in households with unimproved toilet sources were more likely to exclusively breastfeed their infants.

Table 2h highlights the results from the second model (equation 2); where the six separate living environmental factors from equation 1 were combined into the two broader measures described in Table 2c. Infants living in households where all the WaSH facilities were poor or unimproved (*pWaSH*) were less likely to be exclusively breastfed. Similarly, those living in households where adequate building materials (built environment) were poor or completely inadequate (*pbuilding*) were also less likely to be exclusively breastfed. These findings were both statistically significant.

In both model outputs, exclusive breastfeeding was also influenced by the same set of underlying demographic and socioeconomic factors. For example, the odds of exclusive breastfeeding reduce as a child becomes older. Also, being employed, living in an urban area, and having a post-secondary education (higher education) were associated with higher odds of exclusive breastfeeding. Lastly, antenatal visits by mothers were associated with higher odds of

exclusive breastfeeding and there was a significant increase in the practice of exclusive breastfeeding by mothers from 2008 to 2018.

Table 2g: Exclusive breastfeeding of study infants by type of living environmental conditions (equation 1)

Variables	Exclusive breastfeeding (Baseline = non-exclusive breastfeeding)
	Adjusted Odds Ratio (AOR))
Living environmental factors	
unimproved water source	0.97
	[0.84 - 1.12]
unimproved toilet facility	1.14*
	[0.98 - 1.34]
poor stool disposal (when not using the toilet)	0.75**
	[0.65 - 0.87]
inadequate roof	0.97
	[0.78 - 1.19]
inadequate floor	0.79**
	[0.67 - 0.96]
inadequate wall	0.82**
	[0.68 - 0.99]
Demographics	
mother's age	1.00
	[0.99 - 1.01]
child's age	0.73***
	[0.70 - 0.75]
employment (baseline = unemployed)	1.40***
	[1.22 - 1.62]
urban (baseline = rural)	1.45***
	[1.24 - 1.62]
male (baseline=female)	0.89
	[0.79 - 1.02]
higher education (baseline = less than higher education)	1.72***
	[1.37 - 2.16]
married (baseline=unmarried)	0.97
	[0.74 - 1.25]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	1.55***
	[1.28 - 1.91]
> 4 visits	2.08***
	[1.71 - 2.52]
Year effects (baseline = 2008)	
2013	1.36***
	[1.16 - 1.59]
2018	2.14***
	[1.79 - 2.56]

Constant	0.19***
Observations	7472
Pseudo R-squared	0.12

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Table 2h: Feeding patterns of study infants by type of WaSH and built environment (equation 2)

Variables	**Exclusive breastfeeding (Baseline = non-exclusive breastfeeding)**
	Adjusted Odds Ratio (AOR)
Living environmental factors	
Poor water and sanitation (*pWaSH)*	0.69***
	[0.54 - 0.90]
poor building materials (*pbuilding*)	0.81**
	[0.67 - 0.99]
Demographics	
mother's age	1.00
	[0.99 - 1.01]
child's age	0.72***
	[0.69 - 0.75]
employment (baseline = unemployed)	1.46***
	[1.26 - 1.68]
urban (baseline = rural)	1.48***
	[1.28 - 1.70]
male (baseline=female)	0.89*
	[0.78 - 1.01]
higher education (baseline = less than higher education)	1.74***
	[1.39 - 2.16]
married (baseline=unmarried)	0.94
	[0.70 - 1.16]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	1.58***
	[1.30 - 1.92]
> 4 visits	2.24***
	[1.86 - 2.69]
Year effects (baseline = 2008)	
2013	1.37***
	[1.17 - 1.59]
2018	2.29***
	[1.93 - 2.74]
Constant	0.19***
Observations	7638
Pseudo R-squared	0.12

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Relationship between living environmental conditions (WaSH and building material quality) and recent incidents of diarrhea in study infants

The results from both diarrhea and ARI models (Tables 2i and 2j) provide support for the second set of hypotheses (2a and 2b). The results suggest that exposure of an infant to an environment where both WaSH facilities and quality building materials are lacking is associated with increased odds of both diarrhea and ARI. In Table 2i, poor WaSH in a household is significantly associated with higher odds of diarrhea ($p < 0.10$). Similarly, poor building material quality is significantly associated with higher odds of diarrhea ($p < 0.05$). The coefficients on the variable for both poor WaSH facilities and quality building materials from the ARI model (Table 2j) are also greater than 1, indicating higher odds but they are not statistically significant.

Table 2i: Quality of living environmental conditions and recent incidents of diarrhea in study infants (equation 3)

Variables	**Diarrhea**
	Adjusted Odds Ratio (AOR)
poor water and sanitation (*pWaSH*)	1.25*
	[0.96 - 1.59]
poor building material quality (*pbuilding*)	1.28**
	[1.04 - 1.58]
Exclusive breastfeeding (baseline= non-exclusive breastfeeding)	0.74**
	[0.55 - 0.98]
Demographics	
mother's age	1.00
	[0.99 - 1.01]
child's age	1.63***
	[1.31 - 2.01]
child's age squared	0.98
	[0.95 - 1.00]
employment (baseline = unemployed)	1.09
	[0.92 - 1.30]
urban (baseline = rural)	0.77
	[0.71 - 1.08]
male (baseline=female)	0.97
	[0.82 - 1.14]
higher education (baseline = less than higher education)	0.76
	[0.49 - 1.15]
married (baseline=unmarried)	0.98

	[0.70 - 1.36]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	1.37***
	[1.10 - 1.69]
> 4 visits	0.98
	[0.79 - 1.23]
Year effects (baseline = 2008)	
2013	0.88
	[0.73 - 1.07]
2018	1.40***
	[1.12 - 1.76]
Constant	0.02***
Observations	7624
Pseudo R-squared	0.06

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Table 2j: Quality of living environmental conditions and recent incidents of ARI in study infants (equation 4)

Variables	**Acute Respiratory Illness**
	Adjusted Odds Ratio (AOR)
poor building material quality (*pbuilding*)	1.23
	[0.92 - 1.56]
poor water and sanitation (*pWaSH*)	1.14
	[0.83 - 1.57]
Exclusive breastfeeding (baseline= non-exclusive breastfeeding)	0.60**
	[0.40 - 0.82]
Demographics	
mother's age	0.99
	[0.97 - 1.01]
child's age	1.82***
	[1.40 - 2.36]
child's age squared	0.95***
	[0.92 - 0.98]
employment (baseline = unemployed)	1.09
	[0.88 - 1.35]
urban (baseline = rural)	0.76**
	[0.59 - 0.97]
male (baseline=female)	0.93
	[0.76 - 1.14]
higher education (baseline = less than higher education)	1.00
	[0.64 - 1.59]
married (baseline=unmarried)	0.71*
	[0.49 - 1.00]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	2.12***

	[1.61 - 2.77]
> 4 visits	1.63***
	[1.23 - 2.15]
Year effects (baseline = 2008)	
2013	0.76**
	[0.60 - 0.97]
2018	1.48***
	[1.14 - 1.92]
Constant	0.02***
Observations	7626
Pseudo R-squared	0.05

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

The combined effect of the type of infant feeding and living environmental conditions on recent incidents of acute health outcomes in the study infants

The combined effect of both infant feeding type and living environmental conditions in impacting acute health outcomes in infants are highlighted in Tables 2k and 2l. The results in both tables provide support for the third set of hypotheses (3a and 3b). These findings suggest that infants exclusively breastfed and living in households with improved living environmental conditions (WaSH and building material quality) is associated with reduced odds of acute health outcomes (diarrhea and ARI).

Compared to infants exclusively breastfed and living in a household with improved WaSH, infants in other categories where either exclusive breastfeeding, improved WaSH, or both were sup-optimal had higher odds of diarrhea (Table 2k). Similarly, compared to infants exclusively breastfed and living in a household with adequate building material quality, infants non-exclusively breastfed and living in a household with or without adequate building material quality had higher odds of ARI (Table 2l). Though infants exclusively breastfed and living in a household with poor building material quality had lower odds of ARI, this was not statistically significant at all conventional levels.

Table 2k: Impact of both the type of child feeding practice and WaSH conditions on recent diarrhea incidents in study infants (equation 5)

Variables	Diarrhea
	Adjusted Odds Ratio (AOR)
Type of Infant feeding and WaSH variable combined (baseline = exclusive breastfeeding and improved WaSH)	
Non-exclusive breastfeeding and poor WaSH	1.71***
	[1.17 - 2.49]
Non-exclusive breastfeeding and improved WaSH	1.35**
	[1.00 - 1.82]
Exclusive breastfeeding and poor WaSH	1.20
	[0.46 - 3.14]
Demographics	
mother's age	1.00
	[0.99 - 1.01]
child's age	1.63***
	[1.31 - 2.02]
child's age squared	0.98
	[0.95 - 1.00]
employment (baseline = unemployed)	1.09
	[0.92 - 1.30]
urban (baseline = rural)	0.84*
	[0.68 - 1.02]
male (baseline=female)	0.97
	[0.82 - 1.14]
higher education (baseline = less than higher education)	0.75
	[0.49 - 1.15]
married (baseline=unmarried)	0.99
	[0.71 - 1.38]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	1.31***
	[1.06 - 1.62]
> 4 visits	0.92
	[0.74 - 1.14]
Year effects (baseline = 2008)	
2013	0.88
	[0.73 - 1.06]
2018	1.35***
	[1.08 - 1.68]
Constant	0.02***
Observations	7624
Pseudo R-squared	0.06

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Table 2l: Impact of both the type of child feeding practice and building material quality on recent incidents of ARI in study infants (equation 6)

Variables	Acute Respiratory Illness
	Adjusted Odds Ratio (AOR)
Infant feeding and building material quality variables combined (baseline = exclusive breastfeeding and improved building material quality)	
Non-exclusive breastfeeding and poor building material quality	2.05***
	[1.31 - 3.19]
Non-exclusive breastfeeding and adequate building material quality	1.67**
	[1.14 - 2.46]
Exclusive breastfeeding and poor building material quality	0.8
	[0.28 - 2.33]
Demographics	
mother's age	0.99
	[0.97 - 1.01]
child's age	1.76***
	[1.37 - 2.27]
child's age squared	0.95***
	[0.92 - 0.99]
employment (baseline = unemployed)	1.07
	[0.87 - 1.33]
urban (baseline = rural)	0.75**
	[0.59 - 0.96]
male (baseline=female)	0.92
	[0.75 - 1.12]
higher education (baseline = less than higher education)	1.00
	[0.64 - 1.57]
married (baseline=unmarried)	0.72*
	[0.50 - 1.03]
Number of antenatal visits (baseline = no visit)	
0 - 4 antenatal visits	2.12***
	[1.62 - 2.79]
> 4 visits	1.63***
	[1.24 - 2.16]
Year effects (baseline = 2008)	
2013	0.75**
	[0.60 - 0.95]
2018	1.48***
	[1.14 - 1.92]
Constant	0.02***
Observations	7626
Pseudo R-squared	0.05

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Interaction between exclusive breastfeeding and living environmental conditions: effects on infant health

Similar to the results from previous models, tables 2m and 2n also indicate that exclusive breastfeeding and the living environmental conditions of WaSH and the built environment are important determinants of diarrhea and ARI in the first 6 months of infancy. In both the tables for diarrhea and ARI, the protective effect of exclusive breastfeeding was large and statistically significant. Compared to infants who were non-exclusively breastfed, the likelihood of diarrhea and ARI in infants who were exclusively breastfed within the first 6 months of their lives was lower. Exclusively breastfed infants were 26% and 40% less likely to have diarrhea and ARI respectively.

The results from the diarrhea model (table 2m) suggest that exposure of an infant to an environment where all the WaSH facilities were poor increased a child's risk for diarrhea. Additionally, exposure to a household where all the building materials were inadequate or poor was significantly associated with diarrheal disease. Contamination of infants' foods with enteric pathogens is more likely in environments lacking improved WaSH facilities. Thus, eliminating this potential source of exposure to pathogens that cause diarrhea by not feeding infants breast milk substitutes or engaging in exclusive breastfeeding may be most important under poor sanitary conditions.

The model described in equation 7 examined this potential relationship by exploring the interaction between the type of WaSH available in a household and the type of infant feeding and its impact on a child's risk for diarrhea. Though the results indicate that there is no support for hypothesis 4a, as expected in hypothesis 5a, exclusive breastfeeding offers stronger protection against diarrhea for infants living in highly contaminated environments. The interaction coefficient is negative (log odds = -0.05 and AOR=0.95) though not statistically significant (p-

value = 0.93). Among infants who lived in households with poor WaSH facilities, those who were exclusively breastfed were 5% less likely to have diarrhea than those non-exclusively breastfed.

The results of the marginal effect analysis (predictive margins) shown in Appendix 5 and Figure 2d help to better understand the interaction effect in the diarrhea model. The predicted probabilities which are all statistically significant at $p < 0.05$ can be interpreted in two ways. Improved household WaSH is associated with lower odds of diarrhea for infants not exclusively breastfed (8.4% vs 10.1%). Furthermore, the difference in the probability of having diarrhea by exclusive breastfeeding status is greater for infants living in households with unimproved or poor WaSH (7.4% vs 10.1%) than it is for those living in improved (6.4% vs 8.4%). In other words, when the WaSH barrier is absent, the protection afforded by exclusive breastfeeding is higher; providing further support for hypothesis 5a.

Table 2m: Interaction between exclusive breastfeeding and sanitation (pWaSH) in impacting diarrhea outcomes in the study infants (equation 7)

Variables	**Diarrhea**	
	Log odds	**Adjusted Odds Ratio (AOR)**
Exclusive breastfeeding	- 0.30**	0.74** [0.54 - 0.98]
poor water and sanitation (*pWaSH*)	0.22*	1.25* [0.96 - 1.62]
Exclusive breastfeeding**pWaSH*	- 0.05	0.95 [0.34 - 2.58]
poor building material (*pbuilding*)	0.25**	1.28** [1.06 - 1.59]
Demographics		
mother's age	0.01	1.00 [0.99 - 1.01]
child's age	0.49***	1.63*** [1.32 - 2.01]
child's age squared	- 0.02	0.98 [0.95 - 1.00]

employment (baseline = unemployed)	0.09	1.09 [0.90 - 1.28]
urban (baseline = rural)	- 0.13	0.77 [0.69 - 1.04]
male (baseline=female)	- 0.03	0.97 [0.82 - 1.14]
higher education (baseline = less than higher education)	- 0.28	0.76 [0.47 - 1.07]
married (baseline=unmarried)	-0.02	0.98 [0.71 - 1.38]
Number of antenatal visits (baseline = no visit)		
0 - 4 antenatal visits	0.31***	1.37*** [1.10 - 2.67]
> 4 visits	-0.01	0.98 [0.92 - 1.37]
Year effects (baseline = 2008)		
2013	- 0.12	0.88 [0.73 - 1.07]
2018	0.34***	1.40*** [1.14 - 1.79]
Constant	-4.02***	0.02***
Observations	7624	7624
Pseudo R-squared	0.06	0.06

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

The results of the ARI model in Table 2n suggest that exposure to poor building materials in a household (*pbuilding*) is associated with a higher risk of ARI. Additionally, a household with poor water and sanitation (*pWaSH*) is associated with a higher risk of ARI in infants. Like the results in Table 2j, these results are also not statistically significant. The results also show the interaction between exclusive breastfeeding and the building environment variable (*pbuilding*). Similar to the diarrhea model in Table 2m, there is no support for hypothesis 4b. However, in line with hypothesis 5b, the protective effect of exclusive breastfeeding against ARIs is more for infants living in households where adequate building materials are completely absent. The interaction coefficient is negative (log odds = -0.42 and AOR=0.66) though not statistically significant (p-value = 0.45). Infants who are exclusively breastfed in households lacking adequate building materials were 33% less likely to have ARI,

Similar to the marginal effect analysis done with the diarrhea model, all the predicted probabilities were statistically significant (See Appendix 6 and Figure 2e). These results can also be interpreted in two ways. Improved household building material quality is associated with a lower probability of ARI for infants not exclusively breastfed (5.5% vs 6.6%). Furthermore, the difference in probability of having ARI by exclusive breastfeeding status is greater for those living in households with poor building materials (6.6% vs 2.8%) than it is for those living in adequate or improved building materials (5.5% vs 3.4%). In other words, when the built environment barrier is absent, the protection afforded by exclusive breastfeeding is higher; providing further support for hypothesis 5b.

Table 2n: Interaction between exclusive breastfeeding and built environmental condition (pbuilding) in impacting ARI outcomes in study infants (equation 8)

Variables	**Acute Respiratory illness (ARI)**	
	Log odds	**Odds Ratio (OR)**
Exclusive breastfeeding	- 0.50**	0.60**
		[0.41 - 0.87]
poor building material (*pbuilding*)	0.21	1.23
		[0.96 - 1.63]
Exclusive breastfeeding**pbuilding*	- 0.42	0.66
		[0.23 - 2.00]
poor water and sanitation (*pWaSH*)	0.13	1.14
		[0.84 - 1.58]
Demographics		
mother's age	-0.005	0.99
		[0.97 - 1.01]
child's age	0.60***	1.82***
		[1.41 - 2.36]
child's age squared	-0.50***	0.95***
		[0.92 - 0.98]
employment (baseline = unemployed)	0.09	1.09
		[0.86 - 1.33]
urban (baseline = rural)	- 0.28**	0.76**
		[0.58 - 0.94]
male (baseline=female)	- 0.07	0.93
		[0.76 - 1.13]
higher education (baseline = less than higher education)	0.01	1.00

		[0.61 - 1.49]
married (baseline=unmarried)	-0.35*	0.71*
		[0.50 - 1.01]
Number of antenatal visits (baseline = no visit)		
0 - 4 antenatal visits	0.75***	2.12***
		[1.31 - 3.87]
> 4 visits	0.49***	1.63***
		[1.43 - 2.36]
Year effects (baseline = 2008)		
2013	- 0.27**	0.76**
		[0.61 - 0.97]
2018	0.39***	1.48***
		[1.16 - 1.95]
Constant	-4.11***	0.02***
Observations	7626	7626
Pseudo R-squared	0.05	0.05

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; 95% CIs in parentheses*

Figure 2d: Marginal effects of infant feeding practice and type of wash facility on diarrhea incidents

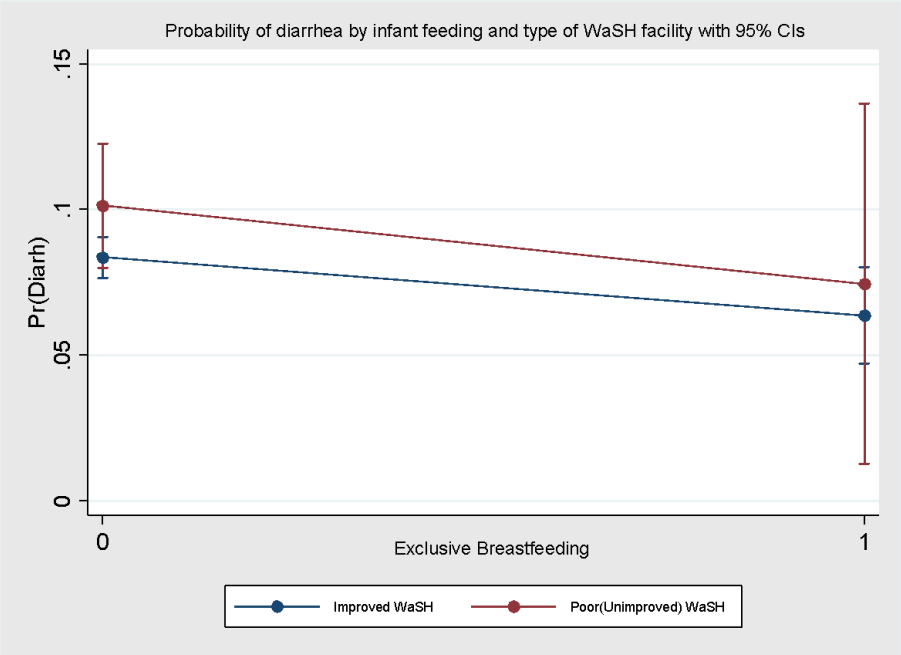
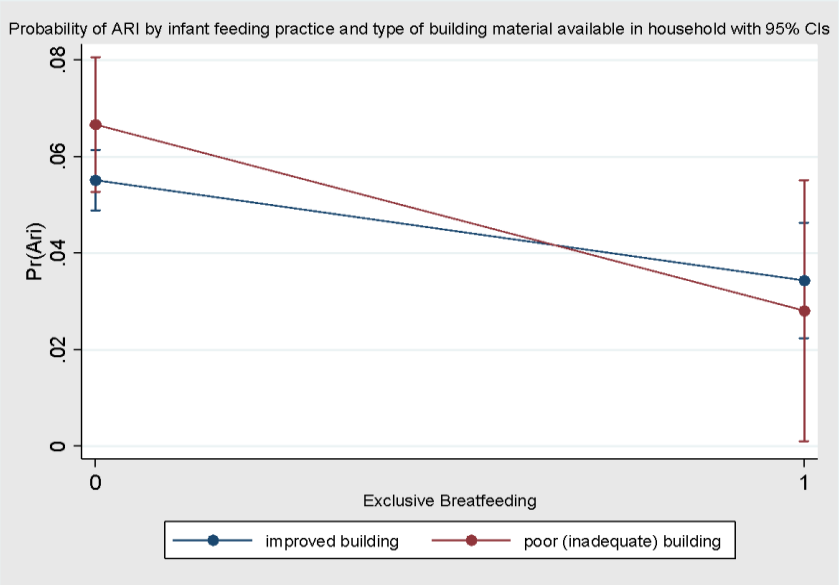


Figure 2e: Marginal effects of infant feeding practice and type of building material on ARI incidents



Discussion

The purpose of this study was to examine the relationships between infant feeding, living environmental conditions, and recent incidents of acute health outcomes in infants living in sub-Saharan Africa. While the results highlighted in this study do not provide cause-and-effect relationships, several important inferences can be made. An important finding from this study was the observed relationship between infant feeding and the quality of a household's built environment or building quality. Infants living in households where all the WaSH facilities were unimproved or poor (*pWaSH*) were less likely to be exclusively breastfed. Similarly, those living in households where all the building materials were inadequate or poor (*pbuilding*) were also less likely to be exclusively breastfed. It is also important to mention that the decision to exclusively breastfeed has also been extensively linked to mothers' socio-economic and demographic

characteristics (Berti & Socha, 2023; Jama et al., 2020; Khan et al., 2017; Gewa et al., 2015). These factors were considered potential confounding variables in all the logistic models used in this study because these factors are also linked to the quality of living environmental conditions an infant is exposed to. Similar to past research, this study also found statistically significant relationships between a mother exclusively breastfeeding and her location of residence, employment status, and educational qualification.

A very important and consistent finding from this study was that exclusive breastfeeding is associated with reduced odds of diarrhea and ARIs for all infants irrespective of the quality of living environment an infant lived in during the first 6 months of life. Compared to infants who were non-exclusively breastfed, exclusively breastfed infants had lower odds of diarrhea and ARIs. Exclusively breastfed infants were 26% and 40% less likely to have diarrhea and ARI respectively.

This study also suggests that the living environmental conditions of WaSH and the built environment were important determinants of diarrheal disease. The exposure of an infant to an environment with poor WaSH was associated with increased odds of diarrhea. Similarly, infants exposed to an environment where the quality of the built environment was poor or inadequate had increased odds of ARI. Though the results for the ARI model were not statistically significant, the findings provide useful insights into the potential impact of built environmental conditions on child health outcomes.

Another important addition to the IYCF literature is the examination of how different combinations of breastfeeding doses and quality of living environmental conditions impact infant health outcomes. The results from the models for diarrhea and ARI highlighted in Tables 2k and 2l suggest that infants exclusively breastfed and exposed to improved or adequate living

environmental conditions had the lowest odds of diarrhea and ARI. Overall, the results from the models exploring hypotheses 3 and 5 suggest that the protective effect of exclusive breastfeeding against diarrhea and ARI varied with the quality of an infant's environment.

Though I do not find support for the fourth set of hypotheses (see Tables 2m and 2n), the direction of effect on the interaction coefficient in both the diarrhea model and the ARI model provides support for the fifth set of hypotheses. Overall, the model outputs in these tables suggest that exclusive breastfeeding offers more protection against diarrhea and ARI in situations where living environmental conditions are lacking. The marginal effect analysis and predicted probabilities also provide further support for the fifth set of hypotheses. The marginal effects plots (Figures 2d and 2e) and the predictive probabilities (Appendices 5 and 6) suggest that the probability of diarrhea and ARI for infants living in households where the environmental conditions are poor is less for exclusively breastfed infants.

These results are consistent with findings from similar studies conducted in developing countries like the one examined in this study (VanDerslice et al., 1994; Clemens et al., 1990). Exclusive breastfeeding offered greater protection against diarrhea was greatest where adequate WaSH facilities were completely absent. This relationship between exclusive breastfeeding and the risk of diarrheal outcomes in infancy is most likely due to two factors; maternal antibodies present in breastmilk and reduced exposure to pathogens that are responsible for the disease (VanDerslice et al., 1994). Similarly, exclusive breastfeeding offered greater protection against ARI where adequate building materials were completely absent. This relationship between exclusive breastfeeding and the risk of ARIs outcomes in infancy is most likely due to increased exposure to antibodies present in breast milk that protect infants from microorganisms that are responsible for ARI.

This study has both strengths and limitations. In terms of strengths, this study used the NDHS; a large and nationally representative survey that is considered to be the best available health data from developing countries where comprehensive health data is otherwise absent. In addition, this study utilized pooled cross-sectional data from three time periods. This is something that is lacking in similar studies (Vanderslice et al., 1994; Habitch et al., 1988; Butz et al., 1984). Another unique strength of this study is the robustness of the findings across the many models utilized in the study. For example, the efficacy of exclusive breastfeeding in reducing the odds of acute health outcomes remained the same in the interaction and the breastfeeding dose and environmental exposure combination model (equations 4 and 5). Furthermore, the relationship between living environmental conditions and the odds of acute health outcomes in infants did not change across all the models analyzed in this study.

The main limitation of this study is the use of observational data which cannot fully account for differences in socio-demographic, physiological, and behavioral factors between study participants (Pattison et al., 2019). Though I attempted to adjust for potential confounding variables in the statistical analysis and used time-fixed effects to control for time-related confounders, differences among study participants likely remain and would impact these results. Another limitation of the study is that the use of cross-sectional data makes the results susceptible to reverse causality. The observed relationships between variables may reflect a situation where the outcome variables influence the exposure variable, rather than the other way around (Khan et al., 2015).

The findings from this study have many policy implications for the region as a whole but more specifically for Nigeria. Recently, Nigeria accounted for the highest under-five mortality rates in the region (Sharrow et al., 2022). Furthermore, sub-Saharan Africa has the highest under-

five mortality in the world, and ARIs and diarrhea are significant contributors to this burden (WHO, 2020; Simen-Kapeu et al., 2021). Thus, findings from this study also have broader potential health, economic, and social policy implications not just for Nigeria but for the sub-Saharan African region.

In this present study, the lack of improved or adequate living environmental conditions was an important risk factor for incidents of acute health outcomes in infants. Thus, promoting exclusive breastfeeding in the first 6 months of an infant's life should be encouraged as a way of protecting infants in all environmental settings from acute health outcomes like diarrhea and ARI. As this study has shown, the practice of exclusive breastfeeding was most important for households where living environmental conditions are poor or inadequate. Though the practice of breastfeeding may be already present in many households in a community, the design of programs and policies specifically formulated to encourage exclusive breastfeeding in households lacking adequate and improved living environmental conditions should be prioritized. This is even more important because results from this study also indicate that the practice of exclusive breastfeeding is significantly less where poor living environmental conditions are more common. Thus, programs and interventions that promote appropriate or optimal IYCF practices should consider targeting communities lacking adequate living environmental conditions.

Improved water and sanitation are particularly important in preventing diarrheal outcomes in infants. The results from this study indicate that the protection offered by improved WaSH and built environments in households appear to be greatest for non-exclusively breastfed infants (Appendix 5). Similarly, improved building materials in a household reduce an infant's risk of ARI (Appendix 6). Efforts to reduce both diarrhea and ARI should also focus on

improving the living environmental conditions of households. A first step national and supranational governments in the region can take to reduce the incidence of diarrhea in populations is to provide water and sanitation infrastructure that ensures the availability of potable drinking water and toilet facilities in communities where household lack these facilities. Increasing the availability of water and access to improved stool disposal facilities can go a long way in enabling families to improve hygienic practices in their households as well as their communities. Furthermore, as this study suggests also, exclusive breastfeeding when combined with adequate living environmental conditions significantly reduces the odds of diarrhea and ARIs during infancy.

The implementation of programs or interventions to improve the built environment in a household may be more challenging. Any intervention to improve the built environment of households in communities lacking adequate housing would require huge government and non-governmental investments. However, the underlying factor responsible for households lacking adequate building materials in the region is poverty (Ekeocha & Iheonu, 2021). The United Nations Habitat program defines poverty in terms of the absence of adequate shelter and the provision of structural and design features that ensure the health and well-being of occupants (Thiele, 2002). The absence of these is recognized as the characteristics of slums; overcrowding, illegal or poor building structures, and hazardous locations.

Adequate housing requires adequate income. The lack of this cannot be separated from a lack of state infrastructures that support socioeconomic development and growth (Galea et al., 2005). Because this factor cannot be ignored, long-term solutions to the issue of adequate housing and built environments would require an integrated approach to combating poverty and improving the health and socio-economic well-being of all people who live in slums. Any

intervention aimed at improving housing and neighborhoods in the sub-Saharan region must also go hand in hand with changing the socio-economic future of the region.

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CHAPTER 3: THE STATUS OF POLICIES AND PROGRAMS ON INFANT AND YOUNG CHILD FEEDING: AN EXAMINATION OF SUB-SAHARAN AFRICAN COUNTRIES

Introduction

Interventions to encourage optimal Infant and Young Child Feeding (IYCF) practices aim to reduce malnutrition and improve child health outcomes, especially in regions lacking adequate health infrastructures (Das et al., 2020; Bhutta et al. 2008). Early initiation of breastfeeding, exclusive breastfeeding for the first six months of life, and complementary breastfeeding afterward until 24 months have been highly recommended for infants and young children for decades (WHO, 2023; Mohammed et al., 2023).

In 2002, WHO and UNICEF jointly developed the Global Strategy for IYCF. This provides a framework for action in some essential policy areas aimed at improving through optimal feeding, infant and young child nutritional status, growth, development, health, and overall survival.[5] The strategy, which is intended as a guide for action for all countries, identifies programs and policies with positive impacts and clearly states the responsibilities of governments and non-governmental organizations in meeting the overall aim of encouraging optimal IYCF.

Following this initiative, the Global Breastfeeding Collective (the Collective); a partnership between UNICEF an WHO, developed country scorecards to track progress in seven policy priority areas highlighted in the Global Strategy for IYCF framework. These policy areas are; Increasing investment in programs or policies that promote breastfeeding, Fully implement the International Code of Marketing of Breastmilk Substitutes (The Code), Enact Paid Leave and Work Policies, Implement Baby-friendly Hospital Initiatives, Improve Access to Skilled Breastfeeding Counseling in Health Care Facilities, Encourage Networks that Protect, Promote

[5] https://www.globalbreastfeedingcollective.org/global-strategy-infant-and-young-child-feeding

and Support Breastfeeding (Community Support Programs), and Track and Monitor Progress on Programs and Funding (Monitoring systems). A description and background to these seven policy action areas or priorities are provided in Table 3a. Since 2017, the Collective has reported performance on the indicators of these policy priorities at both the national and global levels to encourage the promotion, protection, and support of breastfeeding in all regions of the world[6].

Globally, sub-Saharan Africa bears a disproportionate burden of under-five child deaths. Recent estimates by the UN Inter-agency Group for Child Mortality (UN IGME, 2022) indicate that several countries from the region would continue to contribute the highest under-five mortality rates compared to the majority of other countries. Undernourished children, especially those not breastfed, face a higher risk of death from childhood diseases (Victora, 2016). According to the WHO, optimal IYCF practices are key to reducing morbidity and mortality of children under five years of age (WHO, 2017).

The efficacy of exclusive breastfeeding in improving nutrition, health, and survival in the first 6 months of life has been extensively demonstrated (Jones et al. 2003; Darmstadt et al. 2005; Bhutta et al. 2008). Furthermore, both exclusive breastfeeding and complementary breastfeeding beyond 6 months up to two years have been shown to provide both short- and long-term protection from acute and chronic illnesses in childhood (Horta, 2019; Nigatu et al., 2019; Santos et al., 2015; Quigley et al., 2007).

The implementation and adoption of policies and programs related to Infant and Young Child Feeding (IYCF) is a key step in the reduction of under-five mortalities. However, there is a paucity of research examining how these policies and programs have been implemented in the sub-Saharan African region. Available studies related to this area of research were conducted in

[6] https://www.globalbreastfeedingcollective.org/global-breastfeeding-scorecard

countries in the global North (Theurich et al., 2019; Gupta et al., 2013; Bosi et al., 2016; Catteneo et al., 2010; Catteneo et al., 2005; Yngve et al., 2001;). More importantly, there are no current studies on the status of policies related to IYCF practices despite readily available data on the performance of countries on IYCF policies and programs.

To the best of my knowledge, no study has examined the status of IYCF policies and programs in sub-Saharan Africa. As stated earlier, this region already bears a disproportionate burden of under-five mortality rates resulting from malnutrition and childhood illnesses; highlighting a need for further research on the progress countries have made in implementing the WHO/UNICEF recommended IYCF policies and programs. This paper provides key findings on the status and implementation of these programs and policies for 49 countries in sub-Saharan Africa using data from the Global Breastfeeding Collective and discusses the way forward for the region.

Table 3a: Policy Areas to Protect, Promote, and Support Breastfeeding based on the Collective's Call to Action Priorities.

s/n	Policy Action Areas	Background	Action Priority
1	Increase Investment in Policies and Programs that Promote Breastfeeding	According to the World Bank, countries would require an investment of $4.70 per child born to reach the World Health Assembly's (WHA) global target for exclusive breastfeeding. Currently, data on government investment in breastfeeding is unavailable[7].	Increase investments in programs and policies that promote, protect, and support breastfeeding.
2	Fully Implement the International Code of Marketing of Breast-Milk Substitutes	Due to the harms associated with the aggressive marketing of breastmilk substitutes (BMS), the International Code of Marketing of BMS specifies adequate restrictions on the promotion of BMS to protect breastfeeding. Effective monitoring of the legislation is also important in ensuring the proper implementation of the code[8].	Fully implement the code with legislation and effective enforcement.
3	Maternity Protection in the Workplace	The International Labor Organization's (ILO) Convention C183 stipulates women should be allowed to take 14 weeks of paid maternity leave.[9] It further recommends that countries take steps to enact policies that provide 18 weeks of maternity leave together with 100% pay covered by public funds (R191).[10]	Enact the recommended paid family leave and workplace policies.
4	Implement Baby-Friendly Hospital Initiative (BFHI)	This initiative encourages countries to integrate the BFHI or "Ten Steps to Successful Breastfeeding" as the standard in all maternity care facilities.[11]	Implement the ten steps to successful breastfeeding in all maternity facilities.
5	Improve Access to Skilled Breastfeeding counseling and training.	Providing counseling on IYCF has been demonstrated to encourage women to breastfeed with the knowledge and the confidence needed for successful breastfeeding practices.[12]	Improve access to skilled breastfeeding counseling in healthcare facilities.
6	Encourage Networks that Protect, Promote	Community support has been shown to help women maintain and improve breastfeeding practices. Through community networks,	Encourage the development and sustenance of networks that protect, promote,

[7] Nurturing the Health and Wealth of Nations: The Investment Case for Breastfeeding. New York, Geneva: UNICEF, WHO, 2017.
[8] Save the Children. Don't Push It: Why the formula milk industry must clean up its act. London: Save the Children, 2018.
[9] ILO. C183-Maternity Protection Convention. Geneva: ILO 2000.
[10] 14 ILO. R191-Maternity Protection Convention. Geneva: ILO 2000
[11] 14 ILO. R191-Maternity Protection Convention. Geneva: ILO 2000
in facilities providing maternity and newborn services: the revised Baby-friendly Hospital Initiative. Geneva: WHO, 2018.
[12] 13 ILO. Care at work: Investing in care leave and services for a more gender equal world of work. Geneva: ILO, 2022.

	and Support Breastfeeding	women can overcome challenges faced in their breastfeeding experiences.	and support breastfeeding.
7	Track Progress on Policies, Programs, and Funding	Monitoring and evaluation are important in helping countries track progress and make informed decisions for the funding and implementation of their breastfeeding programs. The World Breastfeeding Trends Initiative (WBTi) provides an assessment tool to help countries track their progress and also create a plan to address gaps.[13]	Track progress on policies, programs, and funding.

Research Design

Since 2017, the Collective has advocated for countries to achieve optimal levels of performance on policies and programs designed to promote optimal IYCF by launching a scorecard to track progress on the seven policy action areas highlighted in Table 3a. This paper utilizes data available in the global breastfeeding collective scorecard for 2022 to examine the current status of policies and interventions on IYCF in 49 countries in the sub-Saharan African region. The global breastfeeding scorecard provides an impartial picture of the progress countries have made in seven policy action areas to assist policymakers in their assessment of the implementation and adoption of the WHO-UNICEF global strategy for Infant and Young Child Feeding[14]. Countries are thus able to gauge their gaps in these indicators to meet global targets. A goal of the collective is to increase the number of countries reaching the highest level of performance on all these indicators by tracking countries' progress towards achieving global targets for these indicators.

The methodology employed by the Collective for the scorecard uses a four-color traffic light scheme to visually score countries on their performance on policy or program indicators

[13] https://www.worldbreastfeedingtrends.org/p/what-is-wbti

[14] https://www.globalbreastfeedingcollective.org/media/1921/file

associated with the seven-policy action or priority areas. A description of these indicators and how the color scheme is applied to the scorecard is highlighted in Appendix 7. Also highlighted in the table are the sources of data used for the assessment as well as comments on how each indicator was operationalized. Furthermore, the data utilized by the Collective for the breastfeeding scorecard for each country is the most recent data available from either WHO, UNICEF, or the WBTi.

The available data for 49 countries in sub-Saharan Africa was used to provide a visualization of the status of policies and programs that promote, protect and support optimal IYCF practices in the region. The level of achievement on each policy indicator is based on the Collective's color scheme (green to red). Countries substantially aligned with the recommended policies are represented on the map of the sub-Saharan African region as green and the other three colors in descending order of performance are yellow, orange, and red (Appendix 7).

Throughout the paper, a combination of tables and maps is used to describe the implementation of policies and programs associated with the seven policy action areas assessed by the Collective. I also measure each country's overall progress on the implementation of the policies and programs in the seven action priority areas. This was done to identify the clear leaders and laggards in the region.

To do this, scores were assigned to the colors representing a country's level of achievement in each indicator in the seven policy action areas. Green was assigned a score of 4, Yellow; 3, Orange; 2, and Red; 1. All the scores were then added up to measure each country's overall level of achievement across the seven policy action areas with the highest possible score being 28.

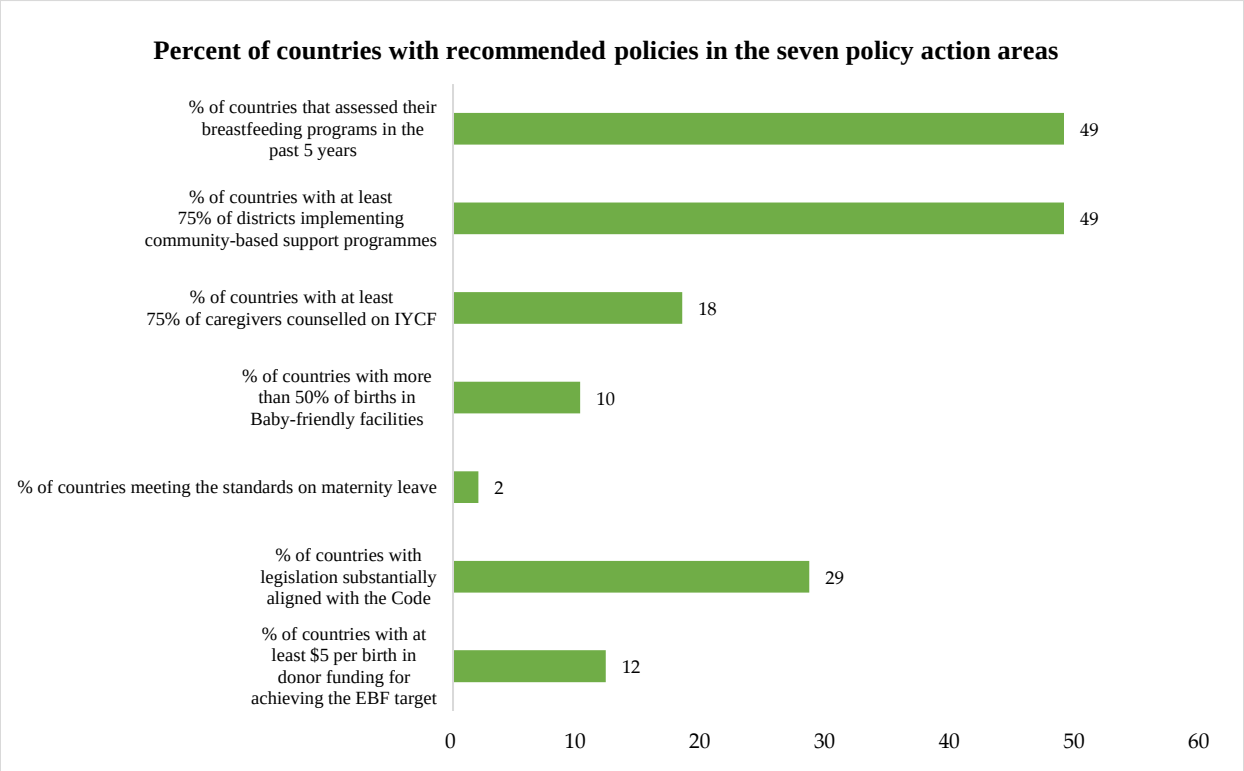
Results

Percent of countries with recommended policies to protect, promote, and support breastfeeding in the sub-Saharan African region

Figure 3a shows the percentage of countries in the region with the recommended implementation of policies or programs associated with the Collective's seven policy action areas in 2022. While there is an appreciable level of compliance by countries (49%) in two policy action areas (Track and Monitor Progress on Programs and Funding and Encourage Networks that Protect, Promote and Support Breastfeeding), countries in the region still have a long way to go in the remaining five policy priority areas. For example, only one country in the region as of 2022 has met the international labor standards of 18 weeks of maternity leave together with 100% pay covered by public funds.[15] Only in 10% (n=5) of the countries do more than 50% of births occur in baby-friendly facilities. 18% (n=9) of the countries have at least 75% of caregivers counseled on IYCF. Countries with legislation substantially aligned with the International Code of Marketing of Breast-Milk Substitutes are few; 29% (n=14) of countries in the region. Lastly, only 12% (n=6) of the countries in the region receive at least $5 per birth in donor funding.

[15] 14 ILO. R191-Maternity Protection Convention. Geneva: ILO 2000

Figure 3a: Percent of countries meeting the recommended implementation of policies to protect, promote, and support breastfeeding (N=49).



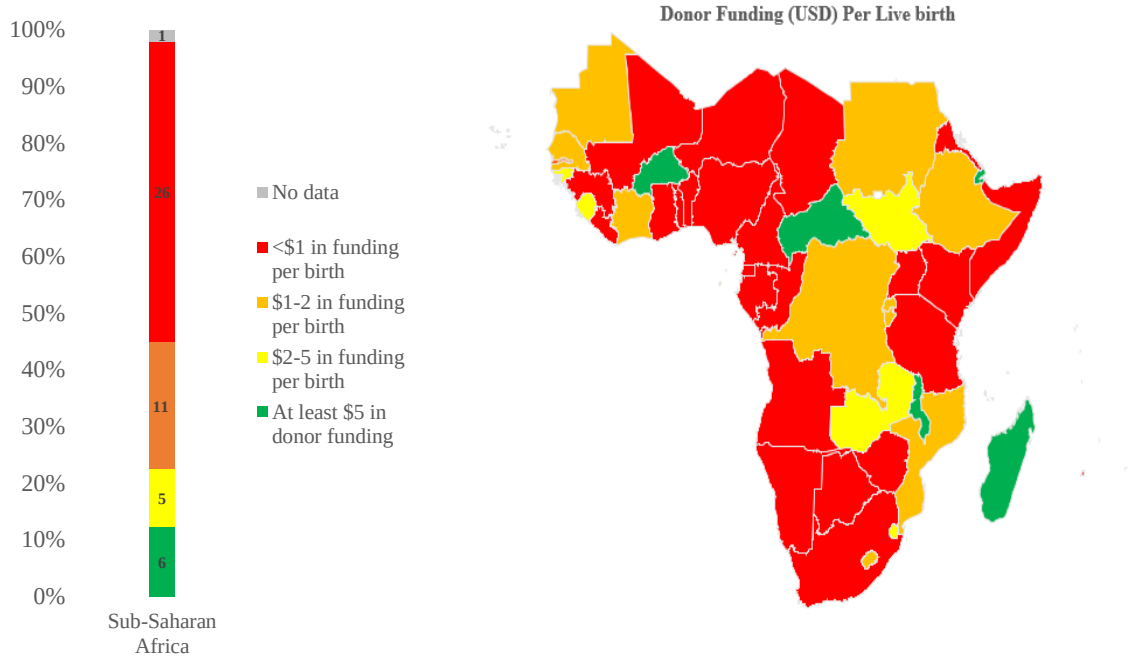
The current state of each indicator in the seven policy action areas

Donor Funding (USD) Per Live Birth

This indicator measures the amount of financial support that countries receive from international donors to support maternal and child health programs including policies to protect, promote, and support optimal IYCF. The World Bank recommends $4.70 per newborn to meet the World Health Assembly's (WHA) global target for exclusive breastfeeding (UNICEF & WHO, 2017). Figure 3b shows that as of 2022, donor funding of greater than $5 per live birth is substantially low in the region. Out of the 49 countries examined in the region, only 6 meet the World Bank recommendation of $4.70 in donor funding. More than half of the countries (n=26) in the region have less than 1 dollar per live birth from donor funding to support policies that

protect and promote optimal IYCF. Though the benefits of investments in optimal IYCF interventions have been extensively demonstrated in research, the funding gap in the region is still wide. There are no regional patterns in this policy indicator but countries with less than $1 in funding appear to be clustered around West, North, and South Africa.

Figure 3b: Donor funding received by countries (N=49)

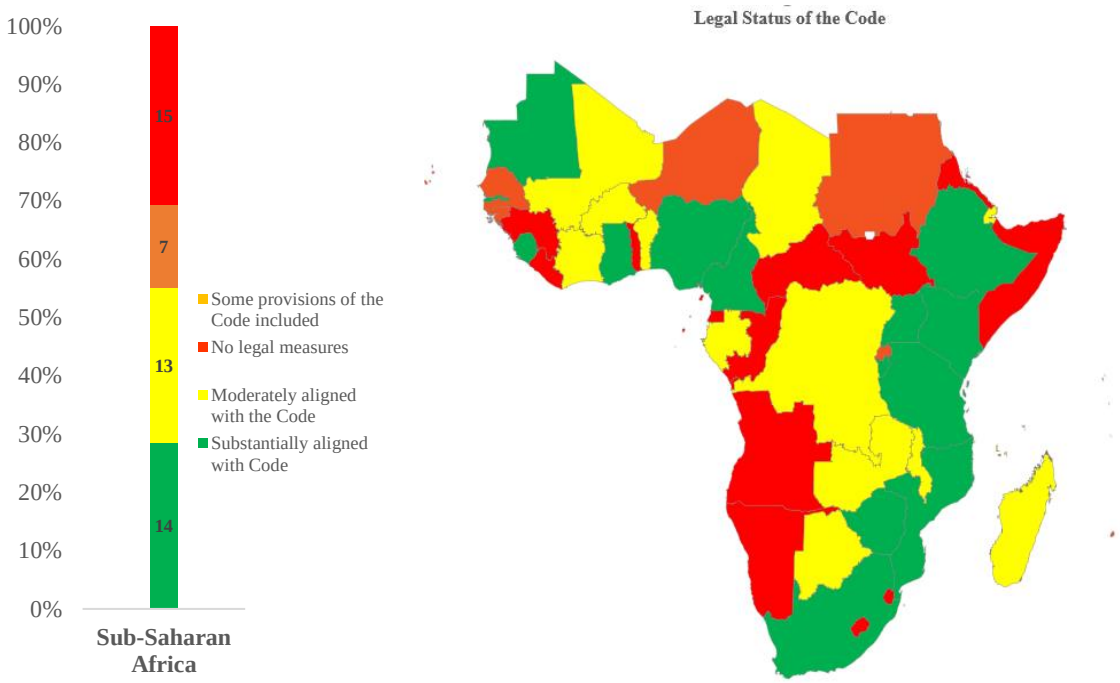


Legal Status of the Code

The International Code of Marketing of Breast-Milk Substitutes (the Code) specifies suitable limitations on the marketing of breast milk substitutes to protect the practice of breastfeeding. The status of the implementation of the Code in the region as of 2022 is highlighted in Figure 3c. Though some countries (n=14) have enacted policies that are substantially aligned with the Code, many countries are yet to fully implement the Code. The policy landscape shows no clear pattern or clustering of countries in terms of adoption but there

is a clustering of slow adopters among the central African countries. About 30% (n=15) of the countries in the region still have no legislation or legal measures in place.

Figure 3c: Legal status of the Code as enacted in countries, sub- Saharan Africa (N=49)

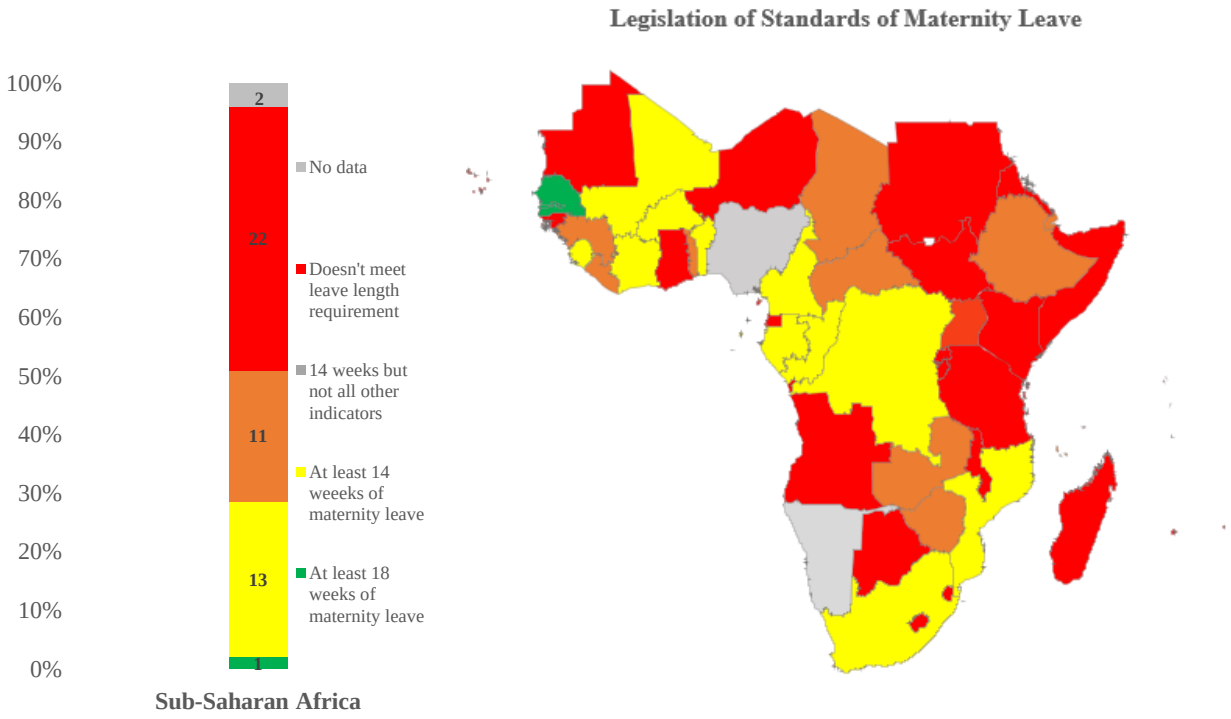


Standards on Maternity Leave

Providing women with longer lengths of maternity leave has been associated with optimal IYCF practices like early initiation of breastfeeding and exclusive breastfeeding (Chai et al., 2018). According to the International Labor Organization (C183) stipulations, women should be entitled to 14 weeks of paid maternity leave (Addati, 2015). The International Labor Organization also recommends that countries pass legislations that provide up to 18 weeks of maternity leave with 100% of pay covered by public funds (Addati, 2022). In 2022, only Gambia met the International Labor Organization (recommendation of 18 weeks with complete pay

covered by public funds. About 45% (n=22) of the countries in the region do not meet the requirements of 14 weeks of paid maternity leave. Also, 50% of the countries offer women at least 14 weeks of paid maternity leave with all or some part of their pay covered by a combination of public and private funds.

Figure 3d: Standards on Maternity Leave in countries, in sub-Saharan Africa (N=49)

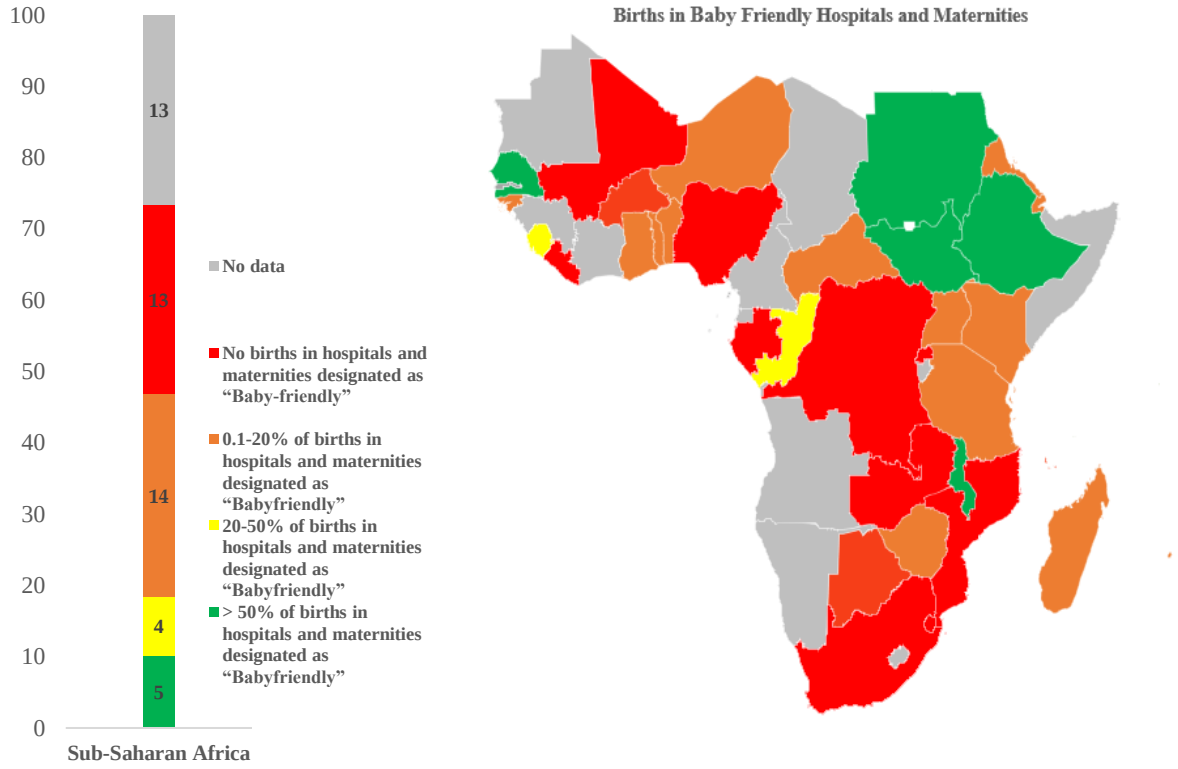


Births in Baby-Friendly Hospitals and Maternities

The Baby-Friendly Hospital Initiative (BFHI) was launched by the WHO and UNICEF in 1991 to encourage practices that protect, promote and support optimal IYCF practices (Mukuria-Ashe, 2023). For a facility to be certified as a baby-friendly hospital (BFH), it must, among other maternity services, implement the ten steps to successful breastfeeding (Walsh et al., 2023). The Collective's score for countries on this indicator is based on the

percentage of babies born in BFHs. Among the countries with data on this indicator, only about 14% (n=5) report that greater than 50% of babies born were born in BFHs (Figure 3d). Furthermore, the data indicate that in 13 countries, there are no births in hospitals and maternities designated as BFHs. This indicator clearly shows that many countries in the region are yet to implement the ten steps to successful breastfeeding in maternity facilities or baby-friendly hospital initiatives in their health facilities.

Figure 3e: Births in Baby-Friendly Hospitals and Maternities, sub-Saharan Africa (N=49)

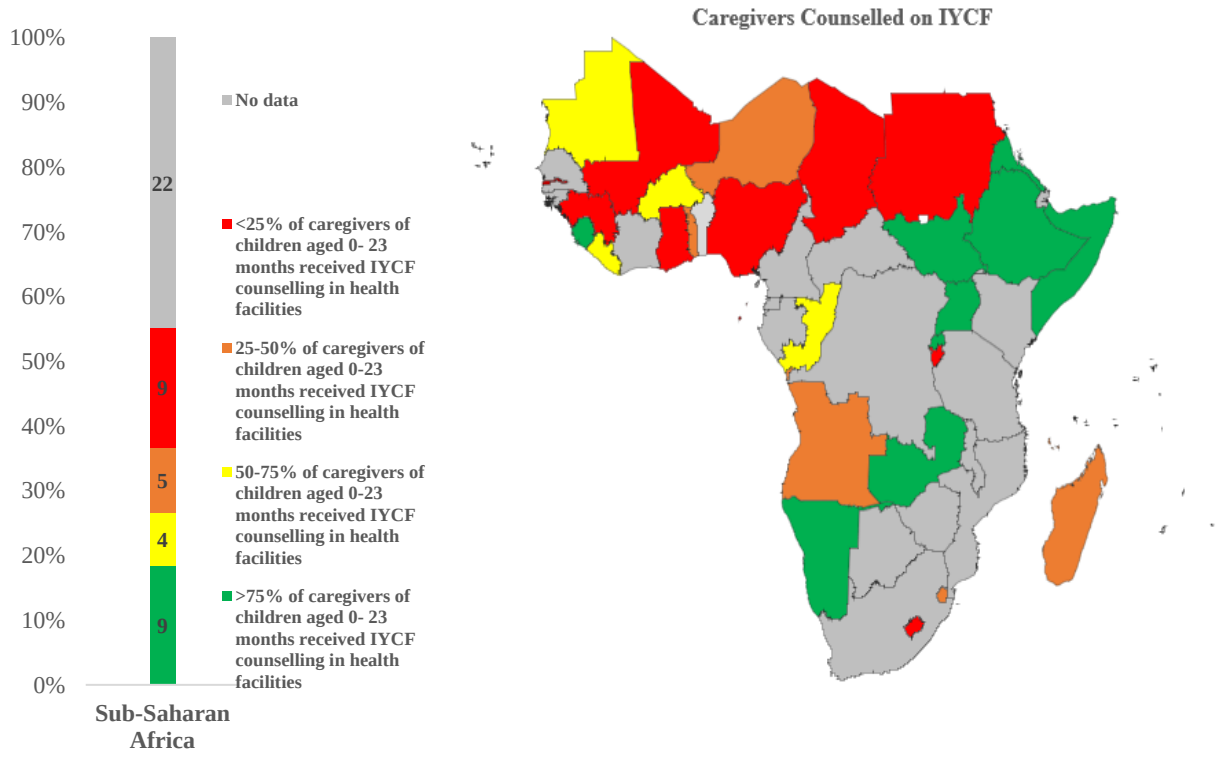


Breastfeeding counseling and training (Caregivers Counselled on IYCF)

Providing timely counseling on IYCF by skilled healthcare practitioners is essential for empowering women to practice optimal IYCF (Sandow, 2022). The most current data on this

indicator shows that, only 18% (n=9) of countries in the region report that at least three-quarters of caregivers with children aged 0 to 2 years were counseled on IYCF practices (figure 3f). Though many countries (n=22) report no data, the figures indicate that many countries in the region (n=18), still fall below the Collective's recommendation. With only 9 countries in the region meeting this recommendation, it is clear that many countries are yet to fully implement policies that improve access to skilled breastfeeding counseling in their healthcare facilities. The figure also shows that countries that report no data are clustered in Central, East, and Southern Africa.

Figure 3f: Caregivers Counselled on IYCF, sub-Saharan Africa (N=49)

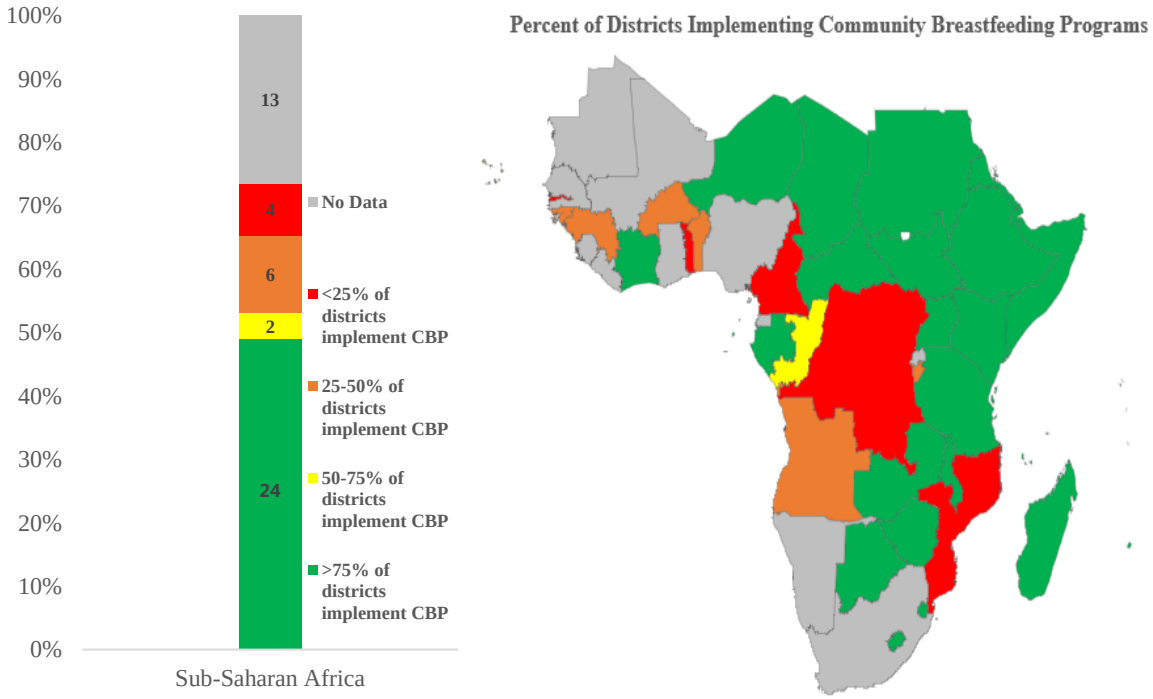


Districts Implementing Community Breastfeeding Programs

Community breastfeeding programs (CBPs) support women in meeting optimal IYCF practices and the associated challenges in meeting their breastfeeding goals. It has been

demonstrated extensively in research that these programs play crucial roles in improving IYCF practices in different contexts and communities (Chepkirui et al., 2020). Though 13 countries in the report have no data on the implementation of this policy, figure 3g indicates that almost 50% of countries in the region report implementing CBPs in more than three-quarters of their districts. Furthermore, only two countries report that 50-75% of their districts have implemented CBPs and only 4 countries report that less than 25% of their districts have implemented CBPs. This is an indication that CBPs have been appreciably implemented in many districts in the region. There is also a regional clustering of countries with widespread implementation of the CBPs; many countries located in parts of Northern and Eastern Africa report having CBPs in over 75% of their districts.

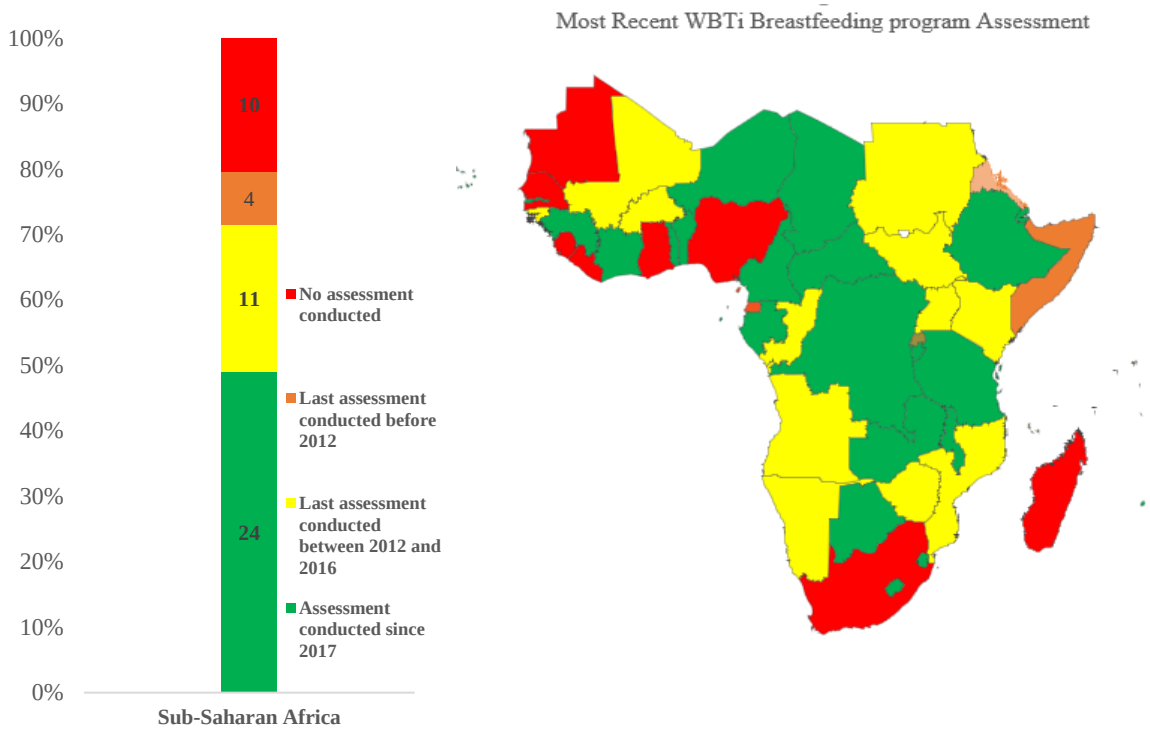
Figure 3g: Districts Implementing Community Breastfeeding Program, sub-Saharan Africa (N=49)



Most Recent WBTi Breastfeeding Program Assessment

Monitoring and evaluation are important for tracking the progress of policies and programs that support IYCF practices. Through monitoring and evaluation, countries learn about the effectiveness of their IYCF policies and programs. This is crucial for making informed decisions for funding and implementation. Recognizing how crucial this factor is to successful IYCF practices and the achievement of global breastfeeding targets, the World Breastfeeding Trends Initiative (WBTi) provides a tool for countries to assess their programs and policies. The Collective recommends that countries track their progress on IYCF policies and programs by conducting an assessment at least once in the five years since the publication of the first breastfeeding scorecard. Figure 3h shows that in 2022, 24 countries clustered around West and Central Africa have completed a WBTi assessment since 2017. Those that fall short of the Collective's recommendations are about 51% of the countries in the region.

Figure 3h: Most recent WBTi Breastfeeding Program Assessment, sub-Saharan Africa (N=49)



Overall progress by countries on Implementation of recommended IYCF programs and Policies

The results in Table 3b show the overall progress countries in the region have achieved in the implementation of policies or programs in the seven policy priority areas. As stated in the methodology, the highest score possible for implementation progress is 28. While no country in the region met this arbitrary standard, Ethiopia's score of 24 translates to an achievement level of about 86% making it the most progressive country and a clear leader in the region. Other leaders in the region are Zambia. Burkina Faso, and South Sudan. They all score relatively high on progress made with levels of achievement above 70%. While the majority of the remaining countries score above 10 points on this index, the average achievement level among these countries is about 54%.

At the far end of this spectrum of achievement are a few countries like Ghana, South Africa, Angola, and Nigeria that score 10 points and below on their progress in the implementation of the IYCF policies. These countries score an average of 30% on their achievement level with the lowest achievement level score by Equatorial Guinea at approximately 18%. While there is no clear regional pattern in the scores attained by countries on implementation progress, the majority of the laggards are geographically located in West Africa.

Table 3b: Countries' Overall Progress on Implementation in the Collective's Seven Policy Priority Areas

Country	*Donor funding (USD) Per Live Birth*	*Status of The Code*	*Standards on Maternity Leave*	*Births in Baby-Friendly Hospitals and Maternities*	*Caregivers Counselled on Infant and Young Child feeding*	*Districts Implementing Community Breastfeeding Programs*	*Most Recent World Breastfeeding Trends Initiative Program Assessment*	*Score*	*% level of Achievement*
Ethiopia	2	4	2	4	4	4	4	24	86
Zambia	3	3	2	1	4	4	4	21	75
Burkina Faso	4	3	3	1	3	2	4	20	71
South Sudan	3	1	1	4	4	4	3	20	71
Comoros	4	3	2	1	2	4	3	19	68
Malawi	4	3	1	4	-	4	3	19	68
Uganda	1	4	1	2	4	4	3	19	68
Djibouti	4	3	2	2	-	4	3	18	64
Sierra Leone	3	4	3	3	4	-	1	18	64
Central African Republic	4	1	2	2	-	4	4	17	61
Congo (Brazzaville)	1	1	3	3	3	3	3	17	61
Madagascar	4	3	1	2	2	4	1	17	61
Sudan	2	2	1	4	1	4	3	17	61
Zimbabwe	1	4	2	2	-	4	4	17	61
Cape Verde	1	4	1	3	-	3	4	16	57
Côte d'Ivoire	2	3	3	-	-	4	4	16	57
Eswatini	3	1	1	1	2	4	4	16	57
Gabon	1	3	3	1	-	4	4	16	57
Kenya	1	4	1	2	-	4	4	16	57
Niger	1	2	1	2	2	4	4	16	57
Tanzania	1	4	1	2	-	4	4	16	57
Benin	1	3	3	2	-	2	4	15	54
Chad	1	3	2	-	1	4	4	15	54
Eritrea	1	1	1	2	4	4	2	15	54

Table 3b (continued)

Country	*Donor funding (USD) Per Live Birth*	*Status of The Code*	*Standards on Maternity Leave*	*Births in Baby-Friendly Hospitals and Maternities*	*Caregivers Counselled on IYCF*	*Districts Implementing Community Breastfeeding Programs*	*Most Recent WBTi Breastfeeding Program Assessment*	*Score*	*% level of Achievement*
Botswana	1	3	1	1	-	4	4	14	50
Burundi	2	4	1	-	1	2	4	14	50
Congo (Democratic Republic)	2	3	3	1	-	1	4	14	50
Mauritius	1	2	1	2	-	4	4	14	50
Mozambique	2	4	3	1	-	1	3	14	50
São Tomé and Príncipe	2	1	3	0	-	4	4	14	50
Guinea-Bissau	3	2	1	2	-	2	3	13	46
Lesotho	2	1	1	-	1	4	4	13	46
Rwanda	2	2	1	1	4	-	3	13	46
Somalia	1	1	1	-	4	4	2	13	46
The Gambia	1	4	4	-	-	-	4	13	46
Togo	1	1	2	2	2	1	4	13	46
Senegal	2	2	3	4	0	-	1	12	43
Cameroon	1	2	3	-	0	1	4	11	39
Guinea	1	1	2	-	1	2	4	11	39
Mauritania	2	4	1	-	3	-	1	11	39
Ghana	1	4	1	2	1	-	1	10	36
Mali	1	3	3	1	1	-	1	10	36
South Africa	1	4	3	1	0	-	1	10	36
Angola	1	1	1	-	1	2	3	9	32
Liberia	1	1	2	1	3	-	1	9	32
Namibia	1	1	0	-	4	-	2	8	29
Nigeria	1	4	0	1	1	-	1	8	29
Seychelles	-	1	2	3	-	-	1	7	25
Equatorial Guinea	1	1	1	-	-	-	2	5	18

Discussion

The Global Strategy for Infant and Young Child Feeding called for increased attention to policies and programs that protect, promote, and support breastfeeding. Optimal infant and young child feeding practices like early initiation of breastfeeding, exclusive breastfeeding, and complementary breastfeeding beyond infancy help protect infants and young children from illnesses that result in high morbidities and mortalities reported in sub-Saharan Africa. Overall, the results indicate that very limited progress has been achieved in the implementation of policies and programs that promote IYCF in sub-Saharan Africa. Furthermore, this limited progress is unequal across the countries in the region. There are stark differences across countries in the overall implementation of policies/programs in the seven policy action areas examined.

The most progress was observed in two policy priority areas; Encourage Networks that Protect, Promote and Support Breastfeeding and Track and Monitor Progress on Programs and Funding. Almost 50% of countries in the region met Collective's recommendation on the indicators for these policy priority areas in 2022. The least progress was observed in two policy priority areas; Increasing Investment in Policies and Programs that Promote Breastfeeding and Maternity protection in the workplace. Less than 11% of countries in the region met Collective's recommendation on the indicators for these policy priority areas in 2022.

Increasing donor funding or investments in the region is crucial for meeting the World Health Assembly's (WHA) global target for exclusive breastfeeding and the World Bank recommends $4.70 per newborn (UNICEF&WHO, 2017). Sustained and predictable funding is necessary to support breastfeeding promotion in the region. Donor funding for breastfeeding promotion in sub-Saharan Africa has fluctuated over the years. For example, it increased in 2013 and decreased in 2015. Furthermore, the majority of the funding came from the United States

government, followed by the United Nations Children's Fund (UNICEF) and the World Bank. Also, there is a clustering of countries with less than 1 dollar per newborn in western and southern Africa with only 1 in both regions (Burkina Faso) meeting the World Bank recommendation.

The results indicate that maternity protection is still lacking in the region. It is imperative for caregivers need to be close to their newborn to practice exclusive breastfeeding successfully during the infant's first six months of life. Furthermore, extensive research indicates that employed women who received more than 12 weeks of maternity leave are more likely to practice optimal IYCF (Mirkovic et al., 2016). The findings in this study indicate that many countries in the region provide less than 14 weeks of maternity leave with different rates of pay covered by either private or public funds. The overall low performance of countries on this indicator for maternity protection in the workplace is a clear indication of the need for urgent policy reforms in the region.

It is important to note that in the region, there are cultural and social norms that make it difficult for women to even advocate for more time off work for maternity (Ejie et al., 2021). Also, many countries in the region face economic challenges which make it difficult for both the public and private sectors to provide adequate financial support for maternity leave (Boswell & Boswell, 2009; Son, 2022). Thus, employers may not be able to afford the pay for maternity leave, and women may not be in a position to take time off work without pay or even advocate for more time off work. Any improvement to meet the ILO recommendations would require a multifaceted approach that addresses these underlying socio-cultural and economic factors.

The results show that the International Code of Marketing of Breastmilk Substitutes has been fully ratified by less than a third of countries in the region. While there is no consistent pattern in the implementation of the Code in the region, the majority of the countries that are substantially aligned with the Code are clustered around Eastern and Southern Africa. Violations of the International Code of Marketing of Breastmilk Substitutes have been documented in various settings and contexts (Aguayo et al., 2003; Hidayana et al., 2017; Lutter et al., 2022). In sub-Saharan Africa, this issue is pervasive even in countries with legislation substantially aligned with the Code. For example, the Global Access to Nutrition Index report for Nigeria found that the baby food market has continued to grow for years reaching an estimated value of NGN 114.9 billion in 2017 (ANIX, 2018; John et al., 2022). In all, while progress has been made with over 70% of the countries in the region having some or all of the provisions of the code included in their legislation, implementation, and enforcement of the code in the region remains a challenge. The widespread and persistent nature of these violations underscores the need for continued efforts to promote and protect breastfeeding and to strengthen regulation and enforcement of the Code.

Though data for performance on the indicator associated with the Ten Steps to Successful Breastfeeding was unavailable for a quarter of the countries in the region, 10% of the countries report that greater than 50% of babies born were born in “Baby Friendly Hospitals” in 2022. While close to 37% of the countries report some percentage of births occurring in “Baby Friendly Hospitals”, about 27% report no births at all in “Baby Friendly Hospitals”. Though it can be argued that incorrect reporting may have occurred in the reporting and recording of data on this indicator, overall, performance on this indicator is poor. One of the many reasons argued for poor performance on this indicator is that healthcare facilities in many countries in the region

may lack the resources to fully implement the Ten Steps to Successful Breastfeeding which are the core components of the BFHI program (Ejie et al., 2021). Also, many women and families in the region may not be able to afford births in facilities that have the resources to implement the BFHI programs.

The performance of countries on their ability to counsel caregivers on IYCF at their healthcare facilities is also very poor. Though there was a dearth of data available from countries on this indicator in 2022, the results indicate that 78% of the countries with data on this policy indicator fall below the Collective's recommendations. Most countries report that less than 75% of caregivers were counseled in the year 2021. The inability of countries to reach global targets or recommendations on this indicator ranges from a shortage of trained healthcare providers to limited access to healthcare (Victora et al., 2016). Multiple reports from the region indicate that healthcare facilities in sub-Saharan Africa lack the resources needed to provide IYCF counseling, including staff, equipment, and educational materials (WHO, 2017). Furthermore, many families in the region are either poor or live in remote or rural areas and may not have access to healthcare facilities or trained healthcare providers who can provide IYCF counseling.

Community support programs are designed to provide information, education, and support to mothers, families, and communities to promote and support optimal breastfeeding practices. They include peer counseling programs, mother-to-mother support groups, and workplace support programs. Though about 27% of the countries in the region have no data on this policy indicator, the results indicate that almost half of the countries in the region meet the recommendations by UNICEF and WHO. 24 countries in the region report that greater than or equal to 75% of districts in their countries implement CBPs. Overall, the performance of countries on this indicator is fair. Again, the level of government support, availability of trained

personnel, and socio-economic and cultural factors are all elements that impact the implementation and success of CBPs in the region.

The availability of monitoring and evaluation systems to track progress on policies, programs, and funding is fundamental in helping countries examine the efficacy of their breastfeeding programs and the progress of implementation. This is crucial for decision-making and mobilization of funds. The results of the associated policy indicator measured by the World Breastfeeding Trends initiative (WBTi) indicate that almost 50% of countries in the region have recent breastfeeding program assessments. Only 5% of the countries in the region have not conducted assessments at all. Weak monitoring and evaluation systems are the result of poor commitment of state institutions, limited resources for monitoring, political instability and conflict, and lack of data availability and quality (Black et al., 2013).

This study has some strengths and limitations. A major strength of this study was the use of data from a source with the most recent information for all the indicators examined. This makes the policy recommendations provided in this study very appropriate and relevant. A major limitation is the lack of data for some of the indicators examined. For example, for the indicator for measuring access to skilled breastfeeding counseling in healthcare facilities, over 40% of the countries in the region lacked data. Also, about 27% of countries in the region lacked data on the implementation of the ten steps to successful breastfeeding (BFHI). This lack of data also emphasizes the need to strengthen the monitoring and evaluation of IYCF.

This study was an examination of the progress on the implementation of policies or programs that promote, protect, and support optimal IYCF practices in sub-Saharan Africa. This is crucial because child nutrition plays a critical role in the short and long-term health outcomes of children. Future studies should also examine time trends in the implementation of these IYCF

policies as well as the relationship between the level of program implementation and child health outcomes in the region. Furthermore, because causal evidence on the impact of optimal IYCF policies on child health outcomes is limited, it would be useful to provide causal evidence by exploring natural experiment scenarios of policy implementation and measuring their impact on selected nutrition and child health outcomes.

Policy Implications

Any improvement to the implementation of IYCF policies and programs in sub-Saharan Africa would require a multifaceted approach that addresses underlying institutional, socio-cultural, economic, and political factors. Broadly speaking, most of the underlying factors acting as barriers to successful implementations of the policies examined in this study are related to funding. First, additional financial resources are needed to support the implementation of IYCF policies and programs, including funding for training, advocacy, and implementation of interventions. Regional governments, international organizations, and donors should be encouraged to mobilize resources to support these efforts in the region.

Secondly, health systems in the sub-region would need to be strengthened to support the implementation of IYCF policies and programs, including the training of healthcare providers in IYCF practices, and improving monitoring and evaluation systems. As stated earlier, the region suffers from inadequate healthcare infrastructure and properly trained personnel. This would require a lot of public and private investments in health care by individual countries in the region. Political will and good governance are important factors that must be considered for the successful strengthening of health systems in the sub-region (Black et al., 2013).

Thirdly, increasing community engagement through culturally appropriate messaging and programs that promote and support breastfeeding and complementary feeding practices is critical

for the successful implementation of CBPs. Strengthening breastfeeding counseling through mentorship is a model currently being employed in Kenya to improve the quality of breastfeeding provided by health workers (Drayton et al., 2023). This model is designed to enhance and maintain the competencies that healthcare providers acquire during the Maternity Staff Training Course for the 2020 Baby-friendly Hospital Initiative (BFHI). Furthermore, regional governments through state institutions should identify and address the barriers that prevent mothers from practicing optimal IYCF, including social norms, cultural practices, and inadequate access to healthcare and support services.

Fourth, IYCF is influenced by multiple sectors, including health, education, human rights, and labor sectors. Governments should promote collaboration across sectors to ensure that policies and programs that impact IYCF are coordinated and complementary. For example, the implementation of policies or programs that provide access to lactation rooms where women can safely express and store breastmilk would require cross and multi-sectoral collaboration with the public and private sectors within countries (Weber et al., 2011; Payne et al., 2010; Fein et al., 2008).

Lastly, governments in the region would benefit from prioritizing the effective implementation of IYCF policies and programs, including the development of clear guidelines, training of healthcare providers, and monitoring and evaluation mechanisms. As stated earlier, the existing World Breastfeeding Trends initiative provides an assessment tool to help countries track their progress and also create a plan to address gaps. The sensitization of governments and institutions in the region about such cost-effective existing resources should be a primary goal of regional health organizations like the West African Health Organization (WAHO), and East African Health Research Commission.

Conclusion

The results indicate that very little progress has been achieved in the implementation of policies and programs that promote IYCF in sub-Saharan Africa. Furthermore, this progress is unequal across the countries in the region. There are stark differences across countries in the implementation of policies/programs in the seven policy action areas examined. This study points out these specific gaps in the policy environment and emphasizes the need for them to be addressed regionally through specific policy prescriptions.

To create an enabling environment that protects, promotes, and supports breastfeeding in sub-Saharan Africa, it is necessary to make further investments and take bold policy actions at a larger scale. This will require more donor funding commitments, stronger monitoring, more investments in healthcare infrastructure, and political will from governments in the region.

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CONCLUSION

Dissertation Summary, Strengths, Limitations

This dissertation explored the nuanced relationship between optimal infant and young child feeding (IYCF) practices, living environmental conditions, and child health outcomes in sub-Saharan Africa. It also examined the status of IYCF policies and programs in this relatively less studied region of the world. Without a better understanding of these relationships or the factors that intersect with IYCF practices to impact child health outcomes, policy prescriptions in the developing countries of sub-Saharan Africa would remain astutely inadequate to address the full spectrum of the challenges that are unique to this region of the world.

Study 1 of the dissertation examined the long-term impact of durations of breastfeeding on recent incidents of diarrhea and ARI post-infancy. The results from this study indicate that longer durations of breastfeeding are associated with fewer incidents of acute respiratory illnesses after breastfeeding has stopped. Children who were breastfed for more than 0-6 months had lower odds of recent incidents of ARIs post-infancy. Overall, the findings support the hypothesis that longer durations of breastfeeding are associated with fewer cases of acute illnesses post infancy at age 24 to 59 months.

These findings demonstrate the long-term protective effect of breast milk from one of the common illnesses contributing to the high under-five mortality rates recorded for decades in sub-Saharan Africa. Though there was no statistically significant relationship between longer durations of breastfeeding and recent incidents of diarrhea, similar studies in the past have reported mixed results (Ogbo et al., 2017; Santos et al., 2015; Lamberti et al., 2011). This study also supports current literature that suggests that child health outcomes are associated with maternal and child sociodemographic characteristics (Ullah et al., 2019; Siziya et al., 2009; El

Gilany et al., 2005). For example, the odds of diarrhea were lower in children whose mothers were married, had a higher education, and who lived in urban areas.

The design of the first study had some unique strengths. The NDHS is a large survey and is considered to be the best available health data from developing countries where comprehensive health data is otherwise absent. This is something lacking in many similar studies on IYCF practices. In addition, I controlled for several confounding factors including some not considered in past research on breastfeeding. Furthermore, though the relationships observed in this study are in no way causal, the study design reduces the potential for reverse causality and temporal ambiguity common in many observational studies like this (Hammerton and Munafo, 2021). The study design was able to establish temporal relationships and thus one can infer the direction of the association.

The main limitation of this study was the use of observational data that cannot fully account for differences in socio-demographic, physiological, and behavioral factors between study participants (Pattison et al., 2019). Though I attempted to adjust for potential confounding variables in the statistical analysis, differences among study participants likely remain and would impact the results. It is also important to acknowledge that this study did not differentiate between exclusive and non-exclusive breastfeeding. The use of "any breastfeeding" duration may potentially reduce the true effect of breastfeeding and bias the results toward the null hypothesis (Ip et al., 2007; Pattinson et al., 2019).

The second study explored the relationships and interactions between household living environmental conditions (WaSH and built environment), IYCF practices, and how this complex relationship impacts child health outcomes. This study tested five different sets of hypotheses. Overall, the results suggest that the quality of water, toilet sanitation, and hygiene (WaSH), and

building materials available in a household are significantly associated with the practice of exclusive breastfeeding. Mothers living in households with poor WaSH facilities and poor building materials were less likely to exclusively breastfeed their infants.

Again, the findings from the second study demonstrated the efficacy of exclusive breastfeeding compared to non-exclusive breastfeeding in reducing the odds of acute health outcomes in infancy. Exclusively breastfed infants were 26% and 40% less likely to have diarrhea and ARI respectively. An important addition to the breastfeeding literature from this study is the examination of how different combinations of doses of breastfeeding and quality of living environmental conditions impact infant health outcomes. The results from this model indicate that infants exclusively breastfed and exposed to adequate living environmental conditions had the lowest odds of diarrhea and ARI.

In other multivariate analyses, exclusive breastfeeding and improved living environmental conditions were significantly and negatively associated with acute health outcomes in infants. Interestingly the results from this study also indicate that there was no significant interaction between exclusive breastfeeding and the quality of the living environment in impacting acute health outcomes in infants. However, the positive effect of exclusive breastfeeding in reducing recent incidents of diarrhea and acute respiratory illness was strongest for infants living in households with poor WaSH facilities and poor building materials. The marginal effect analysis and predicted probabilities suggest that exclusive breastfeeding offers more protection against diarrhea and ARI in situations where living environmental conditions are lacking.

The second study has strengths and limitations similar to the first study. A unique strength of this study, however, is the use of pooled cross-sectional data from three time periods;

something lacking in similar past studies (Vanderslice et al., 1994; Habitch et al., 1988; Butz et al., 1984). Another unique strength of this study is the robustness of the findings across the many models utilized in the study. For example, the efficacy of exclusive breastfeeding in reducing the odds of acute health outcomes remained the same in the interaction and combination model. Furthermore, the relationship between living environmental conditions and the odds of acute health outcomes in infants did not change across all the models tested in this study.

The third and last study described the progress on the implementation of IYCF programs across countries in the region to understand the gaps and challenges that would need to be overcome for the region to meet global and world health assembly (WHA) targets for both child nutrition and health. The findings from the examination of the policy landscape indicate that very limited progress has been achieved on the implementation of policies and programs to promote IYCF in sub-Saharan Africa. More interesting is the stark inequality between countries in the region in terms of progress. While some countries have achieved a good amount of progress on several indicators, others are lagging on most. This study points out specific gaps in the policy environment and emphasizes the need for them to be addressed through unique and context-specific policy prescriptions.

The most progress was observed in two policy priority areas; i) Encourage Networks that Protect, Promote, and Support Breastfeeding and ii) Track and Monitor Progress on Programs and Funding. Almost 50% of countries in the region met the Collective's recommendation on the indicators for these policy priority areas in 2022. The least progress was observed again in two policy priority areas; Maternity protection in the workplace and Increasing Investment in Policies and Programs that Promote Breastfeeding. Less than 11% of countries in the region met the Collective's recommendation on the indicators for these policy priority areas in 2022; for these

indicators, over 45% of the countries did not meet the Collective's recommendation on these indicators.

Like the first and second studies, this study has some strengths and limitations. A major strength of this study was the use of data from a source with the most recent information for all the indicators examined. This makes the policy recommendations provided in this study very appropriate and relevant. A major limitation is the lack of data for some of the indicators examined. For example, for the percentage of caregivers counseled on IYCF, over 40% of the countries in the region lacked data on this indicator. Also, almost 27% of countries in the region lacked data on the implementation of the ten steps to successful breastfeeding (BFHI). This lack of data also emphasizes the need to strengthen the monitoring and evaluation of IYCF in the region.

This study was an examination of the progress on the implementation of policies or programs that promote, protect, and support optimal IYCF practices in sub-Saharan Africa. This is crucial because child nutrition plays a critical role in the short and long-term health outcomes of children; especially in developing countries (Neumann et al., 2004; 2012). Future studies should also examine time trends in the implementation of these IYCF policies as well as explore causal relationships between program implementation and child health outcomes in the region.

Overarching Policy Implications of the Study

The policy implications of the three studies overlap in many aspects. Regionally, sub-Saharan Africa accounts for the highest under-five mortality rates in the world; and ARIs and diarrhea are significant contributors to this burden (WHO, 2022; Simen-Kapeu et al., 2021). Nigeria is uniquely suited as a case study for the sub-Saharan region because it shares similar cultural, socio-economic, political, and demographic characteristics with many countries in the

region. It also accounts for the highest number of deaths from acute health outcomes in children under five years of age in sub-Saharan Africa (UNICEF, 2020). Thus, findings from these studies also have broader potential health, economic, and social policy implications not just for Nigeria but for sub-Saharan Africa and Low and Middle-Income Countries that share similar socioeconomic characteristics with the countries in this region.

This dissertation further supports the promotion of optimal IYCF practices especially in regions disproportionately impacted by high under-five mortality rates. It reemphasizes the promotion of longer durations of breastfeeding for reducing child morbidity not only in the short term but long after breastfeeding has stopped. Overall, the results further demonstrate the uniqueness of breastfeeding as a well-suited health intervention for countries lacking extensive and adequate health infrastructure.

Promoting exclusive breastfeeding in the first 6 months of an infant's life should be encouraged as a way of protecting them in all environmental settings from acute health outcomes like diarrhea and ARI. As this dissertation further suggests, a lack of improved or adequate living environmental conditions increases a child's risk for acute health outcomes. Furthermore, as the results suggest, the practice of exclusive breastfeeding was most important for households where living environmental conditions were poor or inadequate. Thus, programs and interventions that promote appropriate infant-feeding practices should consider targeting communities where adequate living environmental conditions are poor or grossly lacking.

Another step the national governments in the region can take to reduce incidents of diarrhea is to provide public infrastructures that ensure the availability of potable drinking water and toilet facilities for communities lacking improved WaSH facilities in their households. Again, the findings from this dissertation indicate that the protection offered by improved WaSH

and built environments in households appears to be greatest for non-exclusively breastfed infants. The results also suggest that exclusive breastfeeding when combined with adequate living environmental conditions reduces the odds of diarrhea and ARIs during infancy.

Though the implementation of programs or interventions aimed at improving the built environment in a household may be more challenging, it is not impossible. Any intervention to improve the built environment of households in communities lacking adequate housing would require huge government and non-governmental investments. Long-term solutions to the issue of adequate housing in the region would require an integrated approach to combating poverty and improving the health and socio-economic well-being of people who live in slums.

Lastly, this dissertation shows clearly that the current state of implementation of policies and programs that promote, enable, and support optimal IYCF in the region is poor. This has implications for infant and young child health. To create an enabling environment that protects, promotes, and supports breastfeeding in sub-Saharan Africa, national and supranational governments would need to make further investments and take bold policy actions at a larger scale. This will require more donor funding commitments, stronger monitoring, more investments in healthcare infrastructure, and political will from governments in the region.

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APPENDICES

Appendix 1: Effect of any breastfeeding duration on the acute health status of children, 2008 NDHS (Sample of children whose mothers had stopped breastfeeding)

Any breastfeeding duration ***(baseline = 0-6 months)***	**Acute health outcomes**			
	ARI		*Diarrhea*	
	COR	AOR	COR	AOR
7 - 12 months	0.37** [0.16-0.85]	0.38** [0.16-0.87]	1.14 [0.45-2.96]	1.02 [0.39-2.67]
13 - 18 months	0.52* [0.25-1.09]	0.48* [0.22-1.02]	1.98 [0.80-4.89]	1.22 [0.48-3.07]
19 - 24 months	0.54 [0.26-1.14]	0.44** [0.20-0.97]	3.68** [1.49-9.03]	1.56 [0.62-3.92]
>24 months	0.28* [0.07-1.06]	0.28* [0.07-1.12]	1.93 [0.66-5.63]	1.16 [0.39-3.46]

*** significant at p-value less than 0.05; * significant at p-value less than 0.10; COR: crude odds ratio; AOR: adjusted odds ratio*

Appendix 2: Effect of any breastfeeding duration on the acute health status of children, 2008 NDHS (Sample of children whose mothers had stopped breastfeeding for 6 months)

Any breastfeeding duration ***(baseline = 0-6 months)***	**Acute health outcomes**			
	ARI		*Diarrhea*	
	COR	AOR	COR	AOR
7 - 12 months	0.37** [0.16-0.86]	0.37** [0.16-0.86]	1.15 [0.45-2.96]	1.02 [0.39-2.68]
13 - 18 months	0.52* [0.25-1.09]	0.45** [0.21-0.96]	1.97 [0.80-4.85]	1.25 [0.50-3.12]
19 - 24 months	0.51* [0.24-1.07]	0.39** [0.17-0.87]	3.30*** [1.34-8.12]	1.65 [0.65-4.16]
>24 months	0.24* [0.05-1.17]	0.24* [0.05-1.22]	1.48 [0.46-4.81]	1.10 [0.33-3.67]

**** significant at p-value less than 0.01; ** significant at p-value less than 0.05; * significant at p-value less than 0.10; COR: crude odds ratio; AOR: adjusted odds ratio*

Appendix 3: Coding of the X vector variable in the diarrhea model (Equation 5)

Exclusive breastfeeding	Poor WaSH (pWaSH)	Interpretation	Dummy variable
0	1	Non-exclusive and poor WaSH (no protection at all)	Level 0
0	0	Non-exclusive and improved WaSH (single protection from improved water and sanitation)	Level 1
1	1	Exclusive and poor WaSH (single protection from exclusive)	Level 2
1	0	Exclusive and improved WaSH (double protection)	Level 3

Note: The type of Infant feeding and WaSH combined were coded as dummy variables. The omitted dummy was the level 3 dummy

Appendix 4: Coding of the Y vector variable in the ARI model (Equation 6)

exclusive breastfeeding	Poor built environment(pbuilding)	Interpretation	Dummy
	1	Non-exclusive and poor building (no protection at all)	Level 0
0	0	Non-exclusive and adequate building (single protection)	Level 1
1	1	Exclusive and poor building (single protection)	Level 2
1	0	Exclusive and adequate building (double protection)	Level 3

Note: The type of Infant feeding and built environment combined were coded as dummy variables. The omitted dummy was the level 3 dummy

Appendix 5: Predictive margins from the diarrhea model in Equation 6

Type of infant feeding and WaSH facility	Predictive Margins
Non-exclusive x improved WaSH	0.084***
Non-exclusive x poor WaSH	0.101***
Exclusive x improved WaSH	0.064***
Exclusive x poor WaSH	0.074**

**** significant at p-value less than 0.01 ** significant at p-value less than 0.05; * significant at p-value less than 0.10;*

Appendix 6: Predictive margins from the ARI model in Equation 7

Infant feeding and type of housing	Predictive Margins
Non-exclusive x adequate building	0.055***
Non-exclusive x poor building	0.066***
Exclusive x adequate building	0.034***
Exclusive x poor building	0.028**

**** significant at p-value less than 0.01 ** significant at p-value less than 0.05; * significant at p-value less than 0.10;*

Appendix 7: Methodology employed by the collective for the global breastfeeding scorecard (Source: Global breastfeeding scorecard, 2022)

s/n	Action Priority	Indicator(s)	Color Codes and Measurement		Data Source	Comments
1	INCREASE INVESTMENT IN PROGRAMMES AND POLICIES THAT PROMOTE, PROTECT, AND SUPPORT BREASTFEEDING	Donor Funding (USD) Per Live Birth	Green	At least $5 in donor funding per birth	Tracking aid for the WHA nutrition targets (2022)[16]. UN Population Division Data Portal[17].	This indicator was calculated by dividing the amount of donor funding earmarked for exclusive breastfeeding by the number of live births in a country (UN portal 2022). Numbers are in 2015 USD.
			Yellow	$2-5 in funding per birth		
			Orange	$1-2 in funding per birth		
			Red	<$1 in funding per birth		
2	FULLY IMPLEMENT THE CODE WITH LEGISLATION AND EFFECTIVE ENFORCEMENT	Legal Status of the Code	Green	Substantially aligned with the Code: countries have enacted legislation or adopted regulations, decrees, or other legally binding measures encompassing a significant set of provisions of the Code (score of 75 - 100).	Marketing of Breast-Milk Substitutes: National Implementation of the International Code: Status Report 2022[18].	
			Yellow	Moderately aligned with the Code: countries have enacted legislation or adopted regulations, decrees, or other legally binding measures encompassing a majority of provisions of the Code (score of 50 - < 75)		
			Orange	Some provisions of the Code included: countries have enacted legislation or adopted regulations, decrees, or other legally binding measures covering less than half of the provisions of the Code (score of < 50)		
			Red	No legal measures: countries have taken no action or have implemented the Code only through voluntary agreements or other non-legal measures (includes countries that have drafted legislation but not enacted it).		
		Monitoring of the Code	Green	Government is responsible and monitoring is continuously performed.	2021 UNICEF's NutriDash Internal Database[19].	
			Yellow	Government is responsible for monitoring and some monitoring occurred in 2021.		
			Orange	The government was responsible for monitoring but no monitoring occurred in 2021.		
			Red	Government is not responsible for monitoring		

[16] R4D. (2022). Tracking aid for the WHA nutrition targets: Progress toward the global nutrition goals between 2015- 2020. Washington DC: Results for Development
[17] United Nations Population Division Data Portal. Retrieved September 16th, from https://population.un.org/dataportal/home.
[18] WHO, UNICEF, & IBFAN. (2022). Marketing of Breast-Milk Substitutes: National Implementation of the International Code: Status Report 2022. Geneva: World Health Organization
[19] 2021 UNICEF's NutriDash Internal Database, Retrieved October 13th, 2022 from http://www.unicef.org/

Appendix 7 (Continued)

3	ENACT PAID FAMILY LEAVE AND WORKPLACE POLICIES	Standards on Maternity Leave	Green	Meets recommended provisions of Recommendation R191 (at least 18 weeks of maternity leave, 100% of previous earnings paid for by a social program)	Care at work: Investing in care leave and services for a more gender equal world of work (2022)[20].	This indicator was calculated based on three aspects of C183 and R191: length of maternity leave, amount of previous earnings paid during leave, and source of funding. • All updates were made based on the 2022 ILO report. • Duration in days and months as stated in the national legislation was converted into weeks, based on a seven-day week and a 30-day month. Where legislation was in terms of "working days," conversion was based on a five-day week. • Parental leave was counted as maternity leave unless it was explicitly mandated to be taken by the father. • Paid leave before delivery was excluded from the length of paid maternity leave. • Where legislation specified a payment of 100% of salary up to a ceiling, payment was noted as "Meets 183" and not as "the R191 standards" since the application of the ceiling would prevent many mothers from receiving 100% of salary
			Yellow	Meets basic provisions of the Convention C183 (at least 14 weeks of maternity leave, at least 66.7% of previous earnings paid for by a social program regardless of a ceiling)		
			Orange	Meets leave length requirement of Convention C183 (14 weeks) but not all other indicators OR data unclear (this includes countries with variable amounts paid)		
			Red	Doesn't meet the leave length requirement of Convention C183		
		Standards on workplace accommodations	Green	The legislation mandates provisions of both paid breaks and facilities for nursing	Care at work: Investing in care leave and services for a more gender equal world of work (2022)	This indicator was calculated based on two aspects of C183 and R191: Provision of paid nursing breaks and nursing facilities, • Where the legislation specifies the number of workers/female workers, the provision of facilities was noted as "Meets 191."
			Yellow	The legislation mandates only provisions of paid breaks		
			Orange	The legislation mandates only provisions for facilities for nursing		
			Red	There is no legal measure to mandate paid nursing breaks or facilities for nursing		

[20] ILO. (2022). Care at work: Investing in care leave and services for a more gender equal world of work. Geneva: International Labor Organization (https://www.ilo.org/wcmsp5/groups/public/---dgports/--- dcomm/documents/publication/wcms_838653.pdf).

Appendix 7 (Continued)

4	IMPLEMENT THE TEN STEPS TO SUCCESSFUL BREASTFEEDING IN MATERNITY FACILITIES (Baby-friendly Hospital Initiatives)	% of Births in Baby Friendly Hospitals and Maternities	Green	>=50% of births in hospitals and maternities designated as "Baby-friendly"	National Implementation of the Baby-Friendly Hospital Initiative 2017[21].	
			Yellow	20-50% of births in hospitals and maternities are designated as "Baby-friendly"		
			Orange	0.1-20% of births in hospitals and maternities designated as "Baby friendly		
			Red	No births in hospitals and maternities designated as "Baby-friendly"		
		% of Births Observed on Breastfeeding at Birth	Green	>=75% of recent live births observed on breastfeeding at birth	The DHS Program: USAID[22].	
			Yellow	50-75% of recent live births observed breastfeeding at birth		
			Orange	25-50% of recent live births observed breastfeeding at birth		
			Red	<25% of recent live births observed breastfeeding at birth		

[21] WHO. (2017). National Implementation of the Baby-Friendly Hospital Initiative 2017. Geneva: World Health Organization (https://www.who.int/publications/i/item/9789241512381)
[22] USAID (2022). The Demographic and Health Surveys. Retrieved September 13th from https://dhsprogram.com/

Appendix 7 (Continued)

5	IMPROVE ACCESS TO SKILLED BREASTFEEDING COUNSELLING IN HEALTHCARE FACILITIES.	% of Caregivers Counseled on IYCF	Green	>=75% of caregivers of children aged 0- 23 months received IYCF counseling in health facilities	2021 UNICEF's NutriDash Internal Database[23].	
			Yellow	50-75% of caregivers of children aged 0-23 months received IYCF counseling in health facilities		
			Orange	25-50% of caregivers of children aged 0-23 months received IYCF counseling in health facilities		
			Red	<25% of caregivers of children aged 0-23 months received IYCF counseling in health facilities		
		Inclusion of IYCF Support in Pre-service Curricula	Green	IYCF counseling and support are included comprehensively in preservice curricula for both medical doctors and nurses or other health professionals	2021 UNICEF's NutriDash Internal Database.	
			Yellow	IYCF counseling and support are included comprehensively in preservice curricula only for nurses or other health professionals.		
			Orange	IYCF counseling and support are included comprehensively in preservice curricula only for medical doctors		
			Red	IYCF counseling and support are not included comprehensively in preservice curricula for any health professionals.		

[23] World Breastfeeding Trends Initiative. (2022). Retrieved October 10th, 2022 from http://worldbreastfeedingtrends.org/

Appendix 7 (Continued)

6	ENCOURAGE NETWORKS THAT PROTECT, PROMOTE AND SUPPORT BREASTFEEDING	% of Districts Implementing Community Breastfeeding Programs	Green	>=75% of districts implement community breastfeeding programs.	2021 UNICEF's NutriDash Internal Database.	Where 2020 data were missing, the a most recent report from NutriDash 2014-2020 was used.
			Yellow	50-75% of districts implement community breastfeeding programs.		
			Orange	25-50% of districts implement community breastfeeding programs.		
			Red	<=25% of districts implement community breastfeeding programs.		
7	TRACK PROGRESS ON POLICIES, PROGRAMMES AND FUNDING	Most Recent WBTi Breastfeeding Program Assessment	Green	An assessment conducted since 2017	World Breastfeeding Trends Initiative[24].	
			Yellow	Last assessment conducted between 2012 and 2016		
			Orange	Last assessment conducted before 2012		
			Red	No assessment conducted		
		Most Recent Exclusive BF Report	Green	Data collected since 2017	UNICEF Infant and Young Child Feeding Database[25].	
			Yellow	Data last collected between 2012 and 2016		
			Orange	Data last collected before 2012		
			Red	No data collected		

[24] UNICEF. (2022). Infant and young child feeding: Global Database. Retrieved October 21st 2022 from https://data.unicef.org/topic/nutrition/infant-and-young-child-feeding
[25] UNICEF, WHO. (2018). The extension of the 2025 Maternal, Infant and Young Child nutrition targets to 2030. https://data.unicef.org/resources/who-unicef-discussion-paper-nutrition-targets/