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IMPACT OF CHILD HEALTH INTERVENTIONS ON UNDER-FIVE MORTALITY IN GHANA, EVIDENCE FROM 2008 AND 2014 GHANA DEMOGRAPHIC AND HEALTH SURVEYS

BY

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DECLARATION

I, Augusta Soninuor Kolekang, do hereby declare that, except for references to literature and works of researchers which have been duly acknowledged, this thesis is the result of my own original work under the supervision of my supervisors.

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DEDICATION

This work is dedicated to the Almighty God, my parents, siblings and children.

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LIST OF ABBREVIATION AND ACRONYMS

ACT	Artemisinin-based Combination Therapy
AL	Artemether-Lumefantrine
ARI	Acute Respiratory Infection
ARR	Annual Rate of Reduction
AS-AQ	Artesunate-Amodiaquine
C/S	Caesarean Deliveries
CEM	Coarsened Exact Matching
CHPS	Community-based Health Planning Services
DHAP	Dihydroartemisinin-piperaquine
DPT	Diphtheria, Pertussis and Tetanus
GDHS	Ghana Demographic and Health Survey
GDP	Gross Domestic Product
GNMCP	Ghana National Malaria Control Programme
HBC	Home-Based Care
ITN/IRS	Household Insecticide Treated Bed Nets and/or Indoor Residual Spraying
ICCM	Integrated Community Case Management
IMNCI	Integrated Management of Neonatal and Childhood Illnesses
LBW	Low Birth Weight
LiST	Lives Saved Tool
MDGs	Millennium Development Goals

MNCN	Maternal, Neonatal, Child and Nutrition
NHIS	National Health Insurance Scheme
OPD	Outpatient Department
ORS	Oral Rehydration Salt
RDT	Rapid Diagnostic Test
SDGs	Sustainable Development Goals
SP	Sulphadoxine Pyrimethamine
SSA	Sub-Saharan Africa
U5M	Under-five Mortality
WHO	World Health Organization

ABSTRACT

Background: Although under-five mortality (U5M) decreased worldwide and in Ghana in the era of the Millennium Development Goals (MDGs), the decline in Ghana has not been parallel with the level of interventions in maternal and child health. Between 1990 and 2015, there was a 53% decline in mortality among children under-five years globally. Ghana achieved a 50% decline in mortality (119/1,000 live births to 60/1,000 live births) between 1993 and 2014. However, about 6 million under-five deaths were recorded globally in 2015. Under-five mortality decline in Ghana has been considered slow compared to countries at the global level even though there has been an increase in coverage of some of the 26 listed interventions advocated for improving child survival in Ghana. What was not known was the contribution of these interventions to mortality reduction which this study sought to determine.

Objective: The objective of the study was to assess the impact of child health interventions on under-five mortality in Ghana.

Methods: Secondary data of the 2008 and 2014 Ghana Demographic and Health Surveys (GDHS) were analysed for this study. The main data sets comprised 2,992 and 5,884 observations of children under-five years from the 2008 and 2014 data sets respectively. Coarsened Exact matching (CEM) with logistic and Poisson regressions and Lives Saved Tool (LiST) were used for the impact assessment, while logistic and Poisson regressions were fitted to assess the association between these interventions and under-five mortality. The 2008 and 2014 data sets were pooled for the logistic regression and CEM analysis.

Results: There were 6,098 children under-five years and 93 (1.5%) died. Among the children who died, 47 (47.0%) were less than one month old. Fifty-six (56), representing 65.7% of children who died were born to mothers below 35 years. Among the interventions, antenatal care visits coverage level was the highest (84.0%), while water connection in the home had the lowest coverage level (8.1%). About 58 (1.4%) of all children received all eight (8) interventions evaluated at the individual level, and none of those who received all the eight interventions died. Early initiation of breastfeeding reduced odds of death by 58% (aOR = 0.42, 95% CI: 0.2 - 0.8), while clean postnatal care caused a 59% reduction in the odds of death (aOR = 0.41, 95%CI: 0.2-0.9). Interventions that saved the most lives among children under-five years at the population level were malaria control interventions including insecticide treated net and or indoor residual spraying (ITN/IRS) (8,524 lives saved, 16% mortality rate reduction) and artemisinin-based combination therapy (ACTs) (5,702 lives saved, 10% mortality rate reduction), labour and delivery management (skilled delivery) (4,726 lives saved, 8% mortality rate reduction) and pneumococcal vaccine (2,406 lives saved, 8% mortality rate reduction). Reduction in the prevalence of wasting saved 11,918 lives and contributed to a 19% reduction of mortality rate while, reduction in the prevalence of stunting also saved 5,761 lives and contributed to an 11% reduction in under-five mortality rate. However, complementary feeding targeted at reducing mortality via reduction in stunting (-457 lives saved, -1% mortality rate reduction) and wasting (-62 lives saved, 0% mortality rate reduction) resulted in negative lives saved (excess deaths/additional deaths) between 2008 and 2014.

Conclusion: Only two (2), interventions caused mortality reduction at the individual level. A further decline in under-five mortality in Ghana will require increase in the coverage levels of the few high impact interventions, especially those with low coverage levels. Neonatal level interventions should be prioritized, since neonatal mortality decline is slow and the proportion of neonatal deaths is on the increase in Ghana as at the global level. Additionally, attention should be paid to other children at

higher risk of dying including multiple births and children from polygamous homes. Strategies to reduce the prevalence of stunting and wasting would also be beneficial.

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DEFINITION OF TERMS

Impact: Positive or negative, primary or secondary long-term effects produced by an intervention, directly or indirectly, intended or unintended (Hearn & Buffardi, 2016).

Intervention: Any biological agent or action intended to reduce morbidity or mortality.

Causality/causation: The principle that one variable causes a change in another variable.

Intervention effectiveness: The impact of an intervention under real life conditions.

Neonatal mortality: The probability of dying within the first month of life.

Under-five mortality: The probability of dying between birth and the fifth birthday.

CHAPTER ONE

INTRODUCTION

1.1 Under-Five Mortality

Under-five mortality (U5M), the probability of a child dying before age five years from birth, remains a major public health problem despite its decline globally over the years. Globally, between 1990 and 2015, there was a 53% decline in mortality among children under-five years from 90/1,000 live births (12 million deaths) to 43/1,000 live births (6 million deaths), and 52%, from 179/1,000 live births to 86/1,000 live births in sub-Saharan Africa (SSA) (Liu et al., 2016; United Nations, 2015). However, about 6 million under-five deaths were recorded at the end of the period of the Millennium Development Goals (MDGs), with the majority occurring in SSA and southern Asia (Liu et al., 2016; United Nations, 2015). According to Liu et al. (2015), unless the rate of decline of under-five mortality increases, more than 4 million under-five deaths will occur in 2030, with deaths in SSA constituting 60%. However, most countries, including Ghana, are working towards reducing their neonatal mortality rate to about 12/1000 live births and under-five mortality rate to about 25/1000 live births by 2030, in accordance with the Sustainable Development Goals (SDGs) (United Nations, 2015).

Under-five mortality varies within and among regions and countries, and is highest among children in poor and hard-to-reach areas (Rajaratnam et al., 2010) and among children less than one month old (neonates) (Afnan-Holmes et al., 2015). Figure 1 is a map showing the global variation in under-five mortality in 2015.

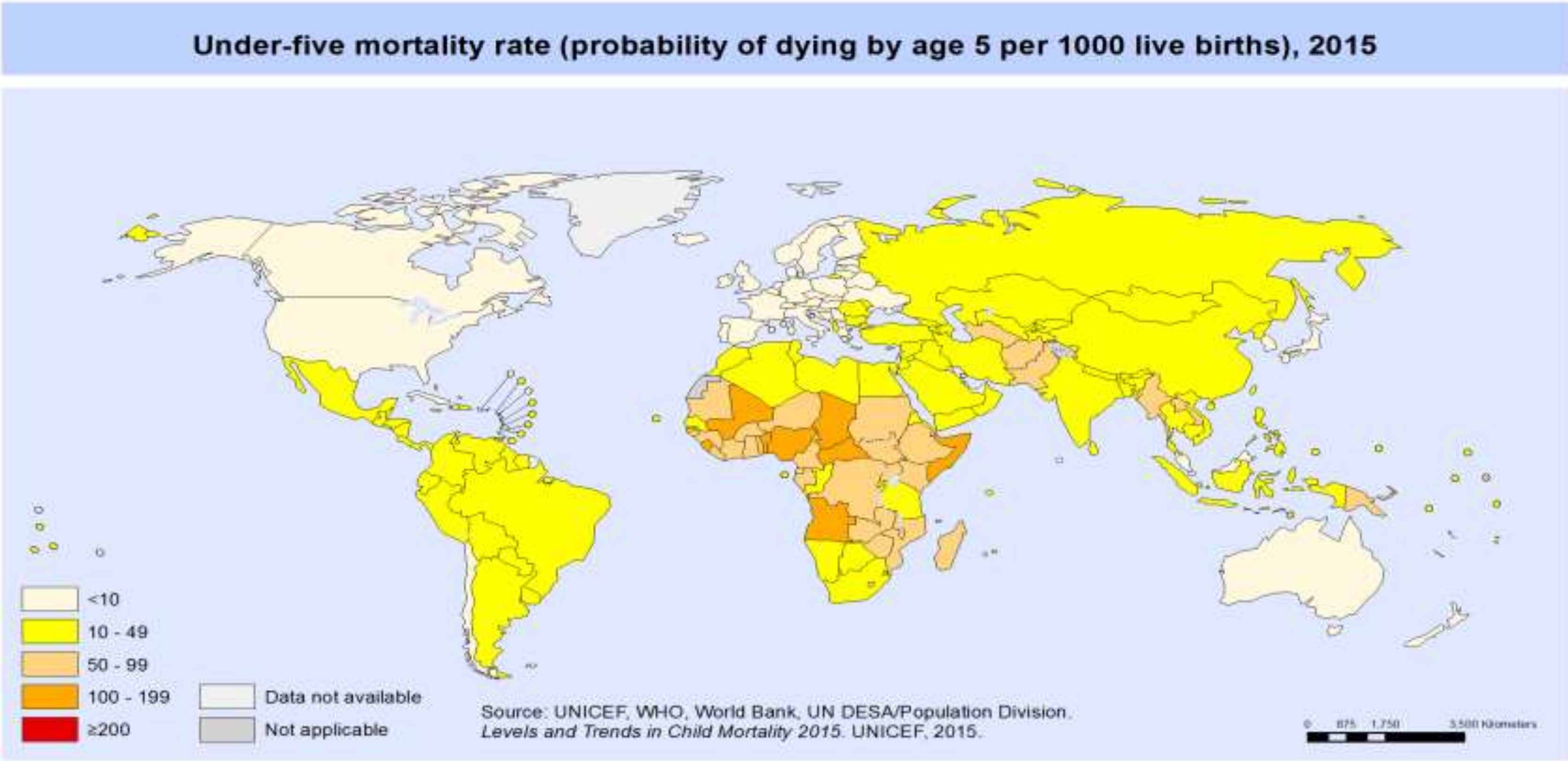


Figure 1: Global Map on Disparities in Under-Five Mortality

Source: WHO, 2015

As with the global variation, U5M rates vary among the previously ten regions of Ghana (Arku et al., 2016; Jankowska, Benza, & Weeks, 2013). Also, results from the Ghana Demographic and Health Surveys (GDHS) and the Multiple Indicator Cluster Surveys (MICS), show that the U5M rate has consistently been higher in the Northern and Upper West regions relative to most of the other regions and the national average (Ghana Statistical Service (GSS), Ghana Health Service (GHS), & ICF, 2015). The Northern, Upper West and Upper East regions are among the poorest regions of the country (Cooke & Hague, 2016). Additionally, the Upper West and Upper East regions have been the most disadvantaged regions, while Greater Accra and Ashanti regions are the least in terms of health human resource capacity in the country (Ghana Health Service, 2014).

Variations in socioeconomic status, household, maternal and child factors (Akseer et al., 2018), prevalence of diseases, risk factors and impact of interventions (Ruducha et al., 2017) underpin the variations in mortality decline. Corsi and Subramanian (2017) found a stronger association between intervention coverage and U5M than economic growth using repeated demographic and health survey data of 36 SSA countries. Among the factors that influence mortality and mortality decline, impact of interventions is one of the most amenable to change. Governments, therefore, introduce interventions or scale-up coverage levels of interventions in order to achieve high coverage levels for a high impact of these interventions on mortality reduction (Afnan-Holmes et al., 2015). There are currently about twenty-seven (27) interventions targeted at reducing under-five morbidity and mortality in Ghana. The most recent addition to the pool of interventions is the malaria vaccine which was introduced in June 2019. Differences in impact of these interventions are expected in different contexts. Even within the same environment, impact will change with changes in the prevalence of diseases and risk factors, and coverage and effectiveness of interventions.

1.2 Causes and Risk Factors of Under-Five Mortality

Most of the causes of U5M are preventable and or treatable infectious diseases (Liu et al., 2012; United Nations, 2015). In 2015, at the end of the Millennium Development Goals (MDGs) and start of the Sustainable Development Goals (SDGs), preterm birth complications (17.8%), pneumonia (15.5%) and intrapartum-related events (11.6%), were responsible for most of the deaths of children under-five years old globally (Liu et al., 2016). In SSA, these were pneumonia (16.6%), preterm birth complications (12.1%) and intrapartum related events (11.5%). Pneumonia was the most common cause of death in SSA, while preterm birth complications were the most common in southern Asia among children under-five years old. At the global level, neonatal causes of death were preterm birth complications (15.9%), intrapartum related events (10.7%) and sepsis or meningitis (6.8%) while causes of death among children 1-59 months globally were pneumonia (12.8%), diarrhoea (8.6%) and injuries (5.5%) (Liu et al., 2016). Additionally, a 61% decline in mortality during the MDGs period globally, was attributed to decrease in mortality due to pneumonia, diarrhoea, intrapartum-related events, malaria and measles (Liu et al., 2016).

Prevalence of these causes of deaths also differed by mortality rates. Pneumonia was the highest cause of death in regions with high mortality rates, while congenital abnormalities were the causes of deaths in areas with low mortality rates among children under-five years old. Preterm births were common both in high and medium mortality rate areas among children under-five years (Liu et al., 2016).

In Ghana, deaths among children younger than five years old in 2013 were due to pneumonia (13%), diarrhoea (8%) and malaria (20%) (World Health Organization, 2015a). Rota virus and *Streptococcus pneumoniae* which cause severe diarrhoea and pneumonia respectively, are vaccine preventable, while the major killers malaria, diarrhoea and pneumonia are treatable (Walker et al., 2013).

Child health promotion services directed at reducing morbidity and mortality, including vaccinations and treatment services, are available at most levels of the healthcare delivery system in Ghana. Preventive interventions such as vaccines and insecticide treated bed nets (ITNs), are distributed at health facilities and in communities. Treatment for malaria, diarrhoea and pneumonia are mostly provided at health facilities, and also at the community and home levels. Pneumonia is treated with antibiotics, malaria with antimalarial drugs and diarrhoea with (ORS) and zinc (Ghana Health Service, 2014). The Ghana Health Service recommends that 90% of children under-five years with malaria be treated with appropriate artemisinin-based combination therapy (ACT) within 24 hours of the unset of symptoms (Ghana Health Service/National Malaria Control Programme, 2017).

Although several child health services exist in several countries, the use of some of the interventions are usually below what is expected in order to achieve the needed mortality reduction (Ayalneh, Fetene, & Lee, 2017; Tefera et al., 2014; Young, Wolfheim, Marsh, & Hammamy, 2012). As reported by Boerma (2018), only immunizations and breastfeeding usually have high coverage levels in most of Western and Central Africa. Inadequate access to, and low use of these services result in low coverage of interventions and consequently, low impact of interventions on mortality decline (Chopra et al., 2013). Additionally, poor quality care can also affect the impact of interventions on mortality even in the event of high use and high coverage of such services (Black et al., 2016). Lack of, and poor quality of healthcare affects neonatal mortality more than other children under-five years. This could be because neonates usually require the services of more skilled health workers and health facilities with some level of adequacy and quality of logistics (Countdown to 2030 Collaboration, 2018).

Inadequate access to, and low use of these interventions, especially in poor and hard-to-reach areas, are cited as the reasons for the lag in progress of child survival improvement in Africa (Geldsetzer et al., 2014; Okwaraji, Cousens, Berhane, Mulholland, & Edmond, 2012; Young et al., 2012). Poor access to care is acknowledged as a problem in Ghana (Ministry of Health, 2016), and according to the United Nations Children Emergency Fund (UNICEF), poverty and poor health services impacts child mortality in Ghana (UNICEF, 2013).

According to the World Health Organization (WHO), globally, among children who die at the hospital, death occurs within 24 hours of admission, which could be due to delay or to inappropriate care seeking practices (World Health, 2016). Delay in treatment can lead to worsening of the disease condition. For example, uncomplicated malaria can progress to severe malaria from hours to days (World Health Organization, 2015b). Two percent of diarrhoea incidents and 12% of pneumonia cases progress to severe disease (Walker et al., 2013).

Severe diseases increase healthcare cost and could undermine the effectiveness of interventions aimed at reducing U5M, since severe diseases are more likely to result in death even with the availability and use of effective treatments. In Ghana, while 93.1% of caregivers in the Volta region and 92.8% in the Northern region sought care for children under-five years for treatment of malaria, diarrhoea and pneumonia (MDP), 89.6% of caregivers in the Volta region and 86.4% from the Northern region sought care from appropriate providers. Also, 38.1% of those who sought care did so within 24 hours of onset of illness in the Volta region and 59.5% in the Northern region. Care-seeking for fever alone within 24 hours was 40.0% in the Volta region and 62.5% in the Northern region (Ferrer et al., 2016).

1.3 Interventions to Improve Use of Health Care Services

Community level child health services have demonstrated potential to lessen child mortality (Awoonor-Williams, Vaughan-Smithb, & Phillips, 2010; Christopher, Le May, Lewin, & Ross, 2011; Freeman et al., 2017; Zaidi et al., 2011) and therefore, been recommended for accelerating decline in U5M. Community level health services increase access to care by bringing care closer to the most disadvantaged (Awor, Wamani, Tylleskar, Jagoe, & Peterson, 2014; Das, Lassi, Salam, & Bhutta, 2013; Freeman et al., 2017; Geldsetzer et al., 2014).

According to Sousa, Tiedje, Recht, Bjelic, and Hamer (2012), universal coverage of interventions targeting the three major diseases, malaria, diarrhoea and pneumonia (MDP), with a community delivery approach, could reduce the annual U5M rate by over 60%, especially in sub-Saharan Africa. A systematic review that included studies in Asia and Africa, also showed that Integrated Community Case Management (ICCM), a community level health service programme, resulted in a 13% increase in care-seeking for treatment of pneumonia, 9% increase in care-seeking for treatment of diarrhoea and 32% reduction in pneumonia specific mortality (Das et al., 2013). In addition, Theodoratou et al. (2010), showed that among developing countries, community case management of pneumonia could reduce pneumonia specific mortality by 70% among children under-five years in SSA.

The Global Action Plan on Pneumonia and Diarrhoea (GAPPD) aims to end preventable deaths from pneumonia and diarrhoea by increasing treatment coverage of diarrhoea with ORS, care seeking for pneumonia and antibiotic treatment of suspected pneumonia to 90% (World Health Organization, 2017). The Every Newborn Action Plan was also launched in 2014, at the global level, with the aim of improving coverage and quality of maternal and neonatal care services for rapid mortality reduction (Kinney et al., 2015; Niermeyer, Robertson, & Ersdal, 2018). Integrated Community Case Management and Home Base Care (HBC) are two of the programmes at the global level targeted at increasing access to treatment for MDP among children under-five years in Ghana.

In Ghana, several strategies have been implemented over the years to increase access to quality healthcare including the HBC, ICCM, the Community-based Health Planning Services (CHPS), National Health Insurance Scheme (NHIS) (Schieber, Cashin, & Saleh, 2012) and Integrated Management of neonatal and Childhood illness (IMNCI). Despites these efforts, coverage levels of some preventive and curative interventions remained low, while mortality remained high (60/1000 live births) in Ghana in 2014. For example, coverage levels of some interventions were 78% (neonatal tetanus vaccination), 55.6% (early initiation of breastfeeding), 48.6% (ORS), 26.2% (ACT) and 22.8% (clean postnatal care) in 2014 (Ghana Statistical Service (GSS) et al., 2015).

1.4 Problem Statement

Under-5 mortality rate in Ghana is high despite several efforts at reducing it (Kayode et al., 2016). Maternal and child health interventions targeted at reducing U5M vary in coverage levels. Coverage levels of some interventions (neonatal tetanus vaccination, early initiation of breastfeeding, oral rehydration salt, artemisinin-based combination therapy and clean postnatal care) remain low in Ghana despite several strategies geared towards increasing access to such services. In Ghana, in 2014, 37.9% of children under-five years old suffering from malaria were treated with ACT. Of those with diarrhoea, 48.6% received ORS, while 7.4% received zinc (Ghana Statistical Service (GSS) et al., 2015). Lastly, 52.6% of those with suspected pneumonia sought care from health facilities or health personnel in 2014.

Coverage levels of these interventions also vary among the various regions of Ghana. From the 2014 GDHS, skilled delivery coverage level was 73.7% nationally, 92.1% in the Greater Accra region, 86.1% in the Ashanti region, 63.1% in the Upper West and 36.5% in the Northern in 2014. Artemisinin-based combination therapy was also 26.2% nationally, 56.8% in the Western region, 26.5% in the Central region and 8.8% in the Northern region in 2014 (Ghana Statistical Service (GSS) et al., 2015). As in other West African countries, coverage of immunizations are among the interventions with the highest coverage levels in Ghana (Boerma, 2018; Ghana Statistical Service (GSS) et al., 2015). Even where coverage is high, quality of interventions can affect their effectiveness and consequently, their impact on mortality.

The causes of low coverage of health services interventions could include low use of services due to individual factors, such as lack of knowledge of available services, poverty, perceived poor quality of health care, beliefs of caregivers about diseases and household decision making. The consequences of low coverage of intervention are low impact of these interventions on mortality, poor health status of children, continuously high U5M, high health care cost and waste of resources. The contribution of each of the interventions such as neonatal tetanus vaccination, early initiation of breastfeeding, ORS, ACT and clean postnatal care to mortality decline or lives saved in Ghana was unknown. This study therefore, sought to evaluate the impact of the various child health interventions on child survival and determine other factors associated with under-five mortality.

1.5 Justification of Study

While efforts are being made to improve child survival through the introduction and scale-up of interventions, mortality decline in Ghana remains slow. The contribution of the various interventions to mortality decline are not known which this study sought to provide. To achieve rapid decline in mortality, and thus, achieve the Sustainable Development Goals 3 target 2 (SDGs) requires, information on interventions that are making the greatest impact on mortality reduction. More importantly, information on those with the potential to rapidly decrease mortality if their coverage levels are scaled up is needed. This will be useful in resource prioritization. The findings from this study might be useful in understanding the trend of child mortality and may mortality decline in Ghana, and provide a baseline information for monitoring progress towards achieving the SDGs.

1.6 Conceptual Framework on Child Mortality

The Mosley and Chen framework (Figure 2) is a widely used framework for studying mortality in developing countries (Mosley & Chen, 1984).

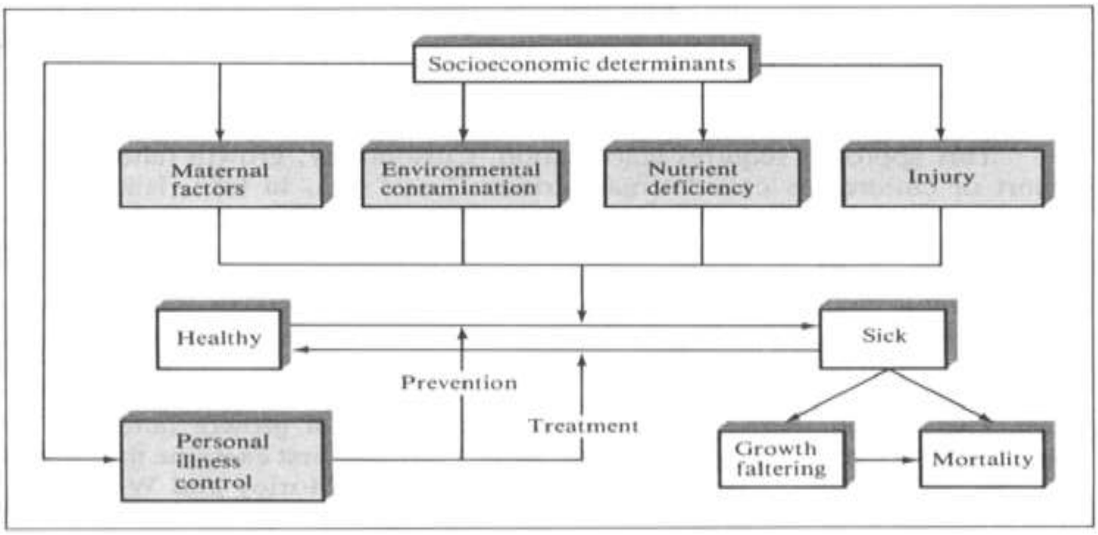


Figure 2: Mosley and Chen Framework for Studying Mortality in Developing Countries (Mosley & Chen, 1984)

This framework was adapted for this study because it incorporates comprehensively, both social and medical determinants of mortality, including interventions targeted at reducing mortality. It has been used in several research works to examine child mortality.(Abir, Agho, Page, Milton, & Dibley, 2015; Charmarbagwala, Ranger, Waddington, & White, 2004; Ezeh, Agho, Dibley, Hall, & Page, 2015; Shifa, Ahmed, & Yalew, 2018; Titaley, Dibley, & Roberts, 2011).

The framework posits that socio-economic factors influence the transition between health and ill-health and vice versa. These socio-economic factors include maternal factors, the environment, nutrition factors and injury. Sickness can lead to recovery, death or growth anomalies. Environmental contaminants include diseases like malaria, diarrhoea and pneumonia, while nutrition factors include low birth weight, stunting and wasting. Maternal factors include age, education, contraceptive use and birth interval, while injury includes burns and accidents. Treatments and preventive measures constitute the interventions and include ACTs, antibiotics for pneumonia, bed nets and vaccines.

Based on the Mosley and Chen, 1984 framework for studying child mortality, the conceptual frame work for this work is presented in Figure 3.

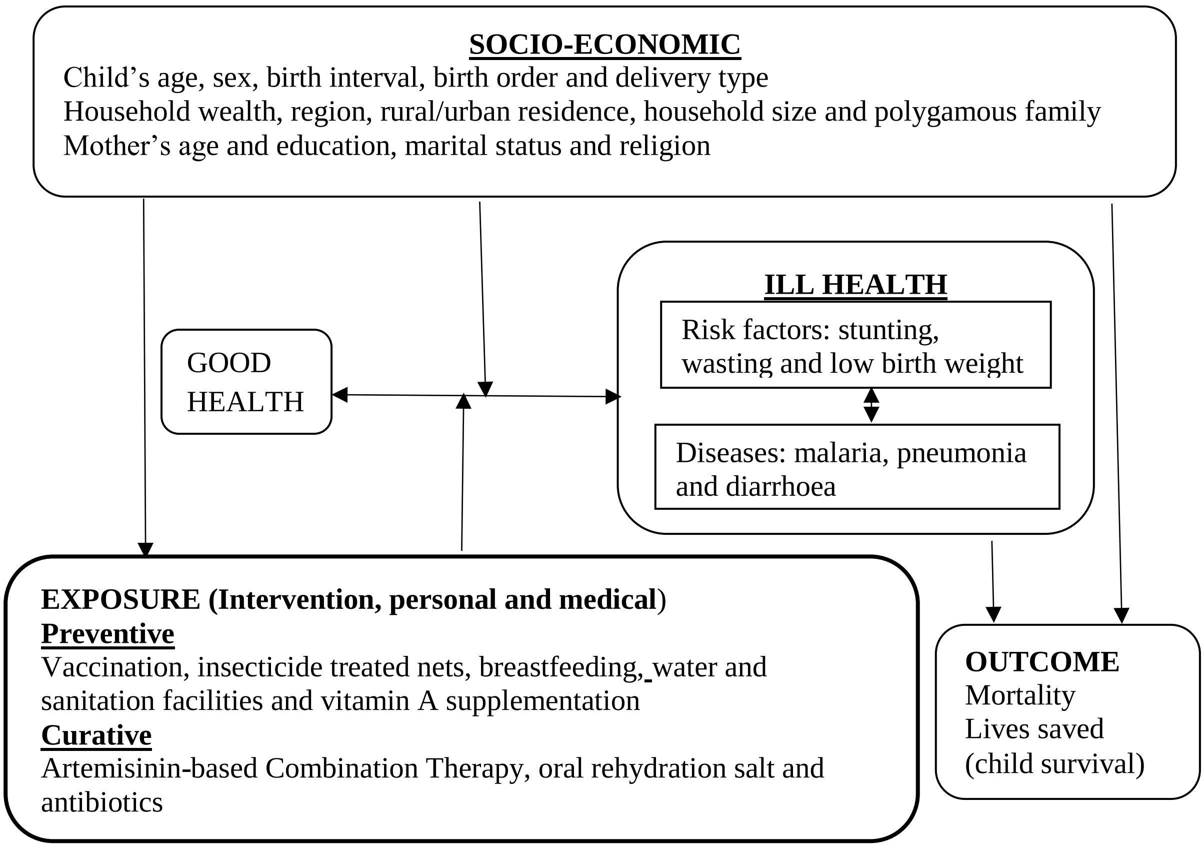


Figure 3: Conceptual Framework on Determinants and Impact of Interventions on Child Mortality

Of all the factors influencing under-five mortality and mortality reduction, interventions targeted at reducing morbidity and mortality can have a direct and immediate impact on morbidity and mortality. Health care services, therefore, deliver these interventions in order to reduce morbidity and mortality. However, the use of these interventions can be influenced by socio-economic factors. These socio-economic factors can also directly influence the risk of mortality. Poor socio-economic conditions reflect in poor and risky living environment, and poor nutrition.

Some of the conditions responsible for child deaths cannot be eliminated or eradicated, and therefore, preventing them from infecting humans through improved personal hygiene, breastfeeding, vaccinations, use of insecticide treated bed nets and treating them when they infect man are the best options. Treatment eliminate the conditions, reduce their spread and limit their potential to cause death in the population. Increased coverage of interventions will lead to improved health status of children, reduced prevalence of diseases and reduced mortality due to these diseases. However, for interventions coverage to be high, such services must be utilised and should be of good quality. Use of interventions, and thus, coverage of interventions is influenced by several child, maternal and household factors. These household, maternal and child factors also directly influence mortality and risk of morbidity. Use of preventive services will reduce chances of morbidity and consequently mortality, while treatment interventions will directly prevent mortality. Risk factors such as low birth weight, stunting and wasting increase the risk of diseases and vice versa.

1.7 Objectives

1.7.1 Main Objective

The main objective of the study was to assess the impact of child health interventions on under-five mortality in Ghana.

1.7.2 Specific Objectives

The specific objectives were:

1. To determine the proportion of children under-five years who died between 2003 and 2014.
2. To evaluate the effect of interventions on child survival.
3. To assess the contribution of the various interventions to mortality reduction.
4. To determine factors that were associated with under-five mortality.

1.8 Research Questions

1. What proportion of children under-five years old died between 2003 and 2014?
2. How did survival differ between children who received interventions and those who did not receive the interventions?
3. Which interventions contributed to the mortality decline experienced within the period?
4. What factors were associated with under-five mortality between 2003 and 2014?

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction to Under-Five Mortality at the Global Level

Under-five mortality (U5M) is still a global health concern, despite decline during the period of the Millennium Development Goals (MDGs) (United Nations, 2015). Under-five mortality varies between and within geographical areas and countries (Arku et al., 2016; Bora & Saikia, 2018; Burke, Heft-Neal, & Bendavid, 2016; Liu et al., 2016; Rajaratnam et al., 2010; Ruducha et al., 2017). Sub-Saharan Africa (SSA) and southern Asia (SA) carry the greatest burden of U5M (United Nations, 2015). In 2015, of the 6 million under-five deaths recorded that translated into 16,000 deaths each day globally, 50% (3 million deaths) occurred in Africa (United Nations, 2015). Also in 2010, of 7.7 million under-five deaths reported, 33% occurred in south Asia (SA) and 49.6% in SSA, while high income countries recorded less than 1% of these deaths (Rajaratnam et al., 2010). Angola, Nigeria, Democratic Republic of Congo, Benin, Central African Republic, Equatorial Guinea, Somalia, Chad, Mali and Sierra Leone were the SSA African countries most affected in terms of U5M in 2015 (Liu et al., 2016).

Evidence suggest that children in poor and hard-to-reach areas are also at higher odds of mortality (Liu et al., 2015). The high mortality in SSA and SA could be related to what is occurring in poor and hard-to-reach areas since these regions are among the poorest regions of the world (Geldsetzer et al., 2014; Okwaraji et al., 2012; Young et al., 2012). Progress in the reduction of neonatal deaths also lags compared to deaths after the neonatal period, with reports of increasing neonatal mortality rates in some countries (Afnan-Holmes et al., 2015; Kanyuka et al., 2016; Kayode et al., 2016). in 2015, of the 6 million under-five deaths recorded, more than 50% (3.8 million) occurred within the neonatal period (United Nations, 2015). In Tanzania, between 2000 and 2012, while the annual rate of decline of under-five mortality was 8.5%, that of neonatal mortality was 4.5% (Afnan-Holmes et al., 2015). Among 187 countries in 2010, neonatal deaths were 3.1 million and post-neonatal 2.3 million, while child deaths were 2.3 million. The annual decline between 1990 and 2010 was 2·1% for neonatal deaths, 2·3% for the post-neonatal deaths and 2·2% of child deaths (Rajaratnam et al., 2010).

Akseer et al. (2018) also observed that during the Millennium Development Goals (MDGs) period, the decline in mortality was lower in Muslim majority countries. The underlying factors affecting mortality distribution result in clustering of mortality even in areas of high mortality decline (Adjuik, Kanyomse, Kondayire, Wak, & Hodgson, 2010; Bhutta & Black, 2013; Golding et al., 2017; Lutambi, Alexander, Charles, Mahutanga, & Nathan, 2010).

2.2 Progress on Under-Five Mortality in Sub-Saharan Africa

Sousa et al. (2012) in 2012 projected that most African countries can only achieve their MDGs target around the year 2065 because of the slow decline in under-five mortality rate in these countries. At the end of the MDGs, although the target of two-third reduction in U5M was not achieved globally, 62 countries achieved it. These comprised all countries in the World Health Organization’s East Asian and the Pacific and Latin America regions. Twelve (12) countries from low and middle income countries and ten from SSA also achieved it (You et al., 2015). An annual rate of decline of greater than 4.4% was required to achieve the target. The fastest decline in U5M rate, annual rate of reduction (ARR) of 8.2%, occurred in eastern Asia (predominantly China) between

2000 and 2015. Based on the evidence in 2015, the global target of MDG4 can possibly be achieved in 10 years post-MDGs.

Among African countries, Live Saved Tool (LiST) estimates showed that Malawi achieved MDG4 in 2013 with a total decline in mortality from 247 to 71 deaths per 1,000 live births from 1990 to 2013 (Kanyuka et al., 2016). This was at an annual rate of decline of 5.4%. Ethiopia also achieved the MDG4, and had a 69% decline in mortality form 166/1,000 live births to 67/1,000 live births. This reduction translated to an annual decline of over 4% (Ruducha et al., 2017). Niger, another country that achieved significant decline (225 /1,000 live births in 1998 to 128/1,000 live births in 2009) in mortality, achieved an annual mortality decline of 5.1% (Amouzou, Habi, Bensaïd, & Group, 2012). Tanzania achieved the MDGs and is projected to achieve the Sustainable Development Goals (SDGs) target on under-five and neonatal mortality (Afnan-Holmes et al., 2015).

Despite the fact that only ten countries, Ethiopia, Eritrea, Liberia, Madagascar, Malawi, Mozambique, Niger, Rwanda, Tanzania and Uganda) in SSA achieved the MDGs target (Liu & Black, 2015), mortality decline accelerated in Africa resulting in African countries experiencing the biggest absolute decrease in under-five mortality during the MDGs period (Cha, 2017; United Nations, 2015). The mortality reduction rate increased from 0.8% before 1995 to 4.2% in 2005 and 2013.

However, Boerma (2018) indicated that although most countries, including those in SSA experienced higher decline in mortality in the year 2000 than previously, a faster decline in mortality than that experienced in the MDGs period will be required to achieved the SDGs. This, some authors criticised as being unrealistic for African countries (Lange & Klasen, 2017) as most African countries, especially those in central and western Africa will require an annual mortality decline of about 8.8% to achieve the SDGs on child survival in 2030 (Golding et al., 2017). Unfortunately, mortality is projected to increase in the African continent (Golding et al., 2017; United Nations, 2015), and a slower rate of decline also in countries with previously high decline (McArthur, Rasmussen, & Yamey, 2018). According to Murray, Laakso, Shibuya, Hill, and Lopez (2007) Latin America, north Africa, the Middle East, Europe and southeast Asia experienced an over 4% annual decline in mortality for over 35years. Therefore, if SSA countries can maintain or improve on the gains made during the MDGs period, the trajectory of child survival might be better than an increase in mortality during the SDGs period as predicted (Requejo & Bhutta, 2015).

2.3 Background to Under-Five Mortality in Ghana

Decline in U5M in Ghana can be considered slow resulting in the non-achievement of the MDG4 target (Kayode et al., 2016). Ghana's U5M rate is high relative to its high health care spending and compared to other countries at the global level (Schieber et al., 2012). According to Schieber et al. (2012), Ghana had a lower U5M compared to most of its neighbours in 1990 at the start of the MDGs. Rates in Ghana were (155/1000 live births in 1987, 119/1,000 live births in 1993 and 108/1,000 live births in 1998, 80/1,000 live births in 2008 and 60/1,000 live births in 2014) (Ghana Statistical Service (GSS) et al., 2015), compared to that in Malawi (247/1,000 live births in 1990) (Kanyuka et al., 2016), Niger (226/1,000 live births in 1998) (Amouzou et al., 2012), Tanzania (132/1,000 live births in 2000), Ethiopia (205/1,000 live births in 1990, 88/1,000 live births in 2011) (Doherty et al., 2016), Bangladesh (151/1,000 live births to 65/1,000 live births from 1990 to 2006) (Cutts et al., 1996). Others were Tunisia, Nigeria, Senegal and Sierra Leone but Malawi, Ethiopia, Tanzania achieved the MDG4. According to the United Nations, inadequate skilled delivery and resources for vaccination and other interventions, poverty, maternal illiteracy and lack of women empowerment contributed to Ghana's inability to achieve the MDG (United Nations/Government of Ghana, 2015).

For Ghana to achieve the SDG3 target 2 by 2030, the under-five and neonatal mortality rates should be at most 25 and 12 deaths per 1,000 live births respectively, implying a yearly under-five and neonatal mortality decline of about 3.7% and 3.6% respectively (Boerma, 2018; United Nations, 2015). These rates of decline that Ghana needs to achieve are low compared to those required by most countries in SSA. Ghana, therefore, has a chance to achieve the SDGs if the right interventions are delivered effectively and socio-economic factors affecting child mortality addressed.

Ghana has recorded a decrease in U5M over the years. According to Nakamura, Ikeda, Stickley, Mori, and Shibuya (2011), mortality decline averaged 1.6% between 1960 and 1990 but increased to 4.6% in 2000. Lives Saved Tool analysis showed a mortality decline from 226 per 1000 live births to 128 per 1,000 live births in 2009, with 59,000 live saved in 2009. In 1990, at the beginning of the MDGs, the U5M rate was 128 per 1,000 live births (WHO, 2015). Within the MDGs period, the mortality rate increased in Ghana by 3.2% between 1998 and 2003 but declined by 27.9% and 25% between 2003 and 2008 and from 2008 to 2014 respectively. Total mortality decline between 2003 and 2014, which is within the MDGs period, was 44.2%, translating into an annual decline of 4.1%. In 2017, neonatal mortality rate was 25/1000 live births and under-five mortality stood at 52/1,000 live births (Ghana Statistical Service (GSS), Ghana Health Service (GHS), & ICF, 2018).

2.4 Regional Level Under-Five Mortality in Ghana

Arku et al. (2016) documented disparities in mortality decline with regions in northern Ghana having lower decline in U5M rate compared to those in southern Ghana. Although the Upper East is in the northern part of Ghana, and is one of the poorest regions in Ghana, and also had one of the highest mortality rates in 1998 (155.6 per 1,000 live births), between 1998 and 2003, the region was the first in the country to achieve a decline in mortality of 79/1000 live births, an annual decline of about 15.3/1,000 live births (Ghana Statistical Service (GSS) et al., 2015). This has been attributed to the implementation of the Community-based Health Planning and Services (CHPS) programme in the region (Awoonor-Williams et al., 2010; Nakamura et al., 2011). The programme led to a decline in U5M rate from 144/1,000 live births to 96/1,000 live births between 1995 and 1998 in the Upper East region. This implies rapid mortality decline is possible among the poor if services are client centred. Pro-poor-client-centred child health interventions strategies such as the CHPS strategy can deliver the needed progress in child health improvement.

Between 1998 and 2003 when the Upper East region experienced such a huge decline in its under-five mortality rate, the Northern region had a decline of 17.3/1,000 live births. During the same period, the Greater Accra region had its U5M rate increase by 13/1,000 live births, while the Upper West region experienced an increase of 52.7/1,000 live births (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS), Ghana Health Service (GHS), & ICF, 2009; Ghana Statistical Service (GSS) &

Macro, 1999). Also, between 2003 and 2008, the Western region also experienced a 40/1,000 live births decline in U5M rates. Furthermore, the Volta and Upper West regions had about 63/1,000 live births and 66/1,000 live births respectively decline in mortality (Ghana Statistical Service, Noguchi Memorial Institute for Medical Research, & ORC, 2004; Ghana Statistical Service (GSS) et al., 2009). However, a closer look at the changes in mortality in the Upper East region reveals that after the period of highest decline, any subsequent declines have been very minimal; 1/1,000 live births between 2003 and 2008, and 6/1,000 live births between 2008 and 2014. Even generally, mortality decline decelerates after the period of high decline in most regions in Ghana. This dynamic points to a possibility of stagnation of mortality decline and a possible mortality increase and is similar to that being observed at the global level.

U5M rate in Ghana since 2003 are 111, 80 and 60 per 1,000 live births for the years 2003, 2008 and 2014 respectively, according to the Ghana Demographic and Health Survey (GDHS) (Ghana Statistical Service (GSS) et al., 2015). With this decline, Ghana could not achieve the MDG 4 which could mean that the mortality decline in Ghana is slow. Ghana needed to achieve an U5M rate of about 40 per 1,000 live births in 2015 to achieve the target, but U5M in 2014 was about 60 per 1,000 live births (Ghana Statistical Service (GSS) et al., 2015).

A further observation of mortality in Ghana by the different age brackets, shows variation in rates and rates of decline of neonatal, post-neonatal, infant and child mortality rates. Decline in neonatal mortality was lower compared to the rest (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Between 2008 and 2014, the decline in neonatal mortality rate was highest in the Upper

West and Western regions, but the Upper East, Ashanti, Greater Accra, Volta and Eastern regions experienced an increased in their neonatal mortality rates. The Upper West, Central and Northern regions are among the poorest regions in the country, yet they experienced decline in their neonatal, post-neonatal, infant, child and U5M rates. The Volta region was the only region that experienced an increase in all neonatal, post-neonatal, infant and child mortality rates. It was therefore, the only region that recorded an increase (22%) in its under-five mortality between 2008 and 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

2.5 Diseases and Risk Factors Affecting Under-Five Mortality

Factors affecting U5M and U5M decline are a combination of socio-demographic factors, prevalence of diseases and risk factors and the use of, and impact of interventions targeting the diseases and risk factors. These factors interact to influence mortality and mortality decline. Their influence on mortality varies during the different stages of life with maternal and demographic factors impacting more on neonatal mortality, while socioeconomic factors contribute the most beyond the neonatal period.

Common childhood illnesses include measles, mumps, rubella, pertussis, poliomyelitis, mumps, chickenpox and diphtheria. Most of these diseases are vaccine preventable. Malaria, diarrhoea, pneumonia and measles are among the major causes of under-five's deaths globally and in Ghana (World Health Organization, 2015a). In 2015, major causes of U5M were preterm birth complications (17%), pneumonia (13%), intrapartum-related events (11%) and diarrhoea (10%). The lowest were measles, pertussis and intrapartum-related events which was each less than 1% (Boerma, 2018). In the neonatal period, major causes were preterm birth complications (16%), intrapartum related events (11%) and sepsis (7%) with the lowest being tetanus and diarrhoea which were each less than 1%. Risk factors included undernutrition comprising low birth weight, stunting and wasting. Among neonates, infections, intrapartum related events (asphyxia) and preterm were the major causes of death (Lawn et al., 2014). Stunting, wasting and low birth weight increase susceptibility to diseases and thus death (Afnan-Holmes et al., 2015).

In Ghana, infection, birth injury and asphyxia and prematurity were major causes of neonatal deaths in the Kassena-Nankana district of the Upper East Region (Welaga et al., 2013). In Kintampo in the Brong Ahafo region of Ghana, causes of deaths in 2003 were infections (40.3%), birth asphyxia (33.2%), prematurity (19.7%), congenital anomalis (2.7%), others (2.7%) and unexplained (1.4%) (Edmond et al., 2008).

2.5.1 Malaria

Malaria is a parasitic disease caused by different species of a parasite called Plasmodium. These include *Plasmodium falciparum, Plasmodium vivax*, *Plasmodium ovale, Plasmodium malariae* and *Plasmodium knowlesi* (Doolan, Dobaño, & Baird, 2009). The severest form of malaria which can result in complications such as cerebral malaria, coma, severe anaemia, multiple organ failure and death is what is caused by *Plasmodium falciparum* (Doolan et al., 2009). *Plasmodium falciparum* is the commonest species of plasmodium in sub-Saharan Africa (SSA) and thus the high malaria morbidity and mortality in SSA. Ghana is a malaria endemic country (Ghana Statistical Service, 2016) with over 80% of cases due to *Plasmodium falciparum* (Ministry of Health, 2014).

The parasites are transmitted to a person through the bite of an infective female anopheles mosquito. A single mosquito bite can result in a disease which could be uncomplicated or complicated/severe malaria. People in malaria endemic countries develop partial immunity to malaria after repeated exposure to mosquito bites and therefore adults are partly immune to malaria (Doolan et al., 2009). However, children between 6 months and 5 years old lack this partial immunity and therefore are the most affected by malaria. Those younger than 6 months of age are protected by maternal antibodies.

Malaria is an important contributor to morbidity and mortality globally, and also in Ghana, although malaria mortality rate decreased by 58% between 2000 and 2015 globally (United Nations, 2015). In Ghana, outpatient cases due to malaria declined by over 57% between 2005 and 2015 (Aregawi et al., 2017). Uncomplicated malaria presents as fever, chills, loss of appetite and anaemia. Malaria if not treated leads to death. Malaria also results in anaemia, haemoglobin (Hb) less than 11g/dl, especially in children under-five years (Ghana Statistical Service, 2016). Malaria parasites cause haemolysis of red blood cells as they infect the cells.

In 2014, malaria accounted for about 27,388,250 (30.9%) of all out-patient illnesses cases and 1,331,239 (15.7%) of cases among children under-five years old in Ghana (National Malaria Control Programme, 2015). Admissions attributable to malaria were 207,913 (48.4%) and deaths were 1,060 (48.2%) among children under-five years (National Malaria Control Programme, 2015). It is the goal of the National Malaria Control Programme (NMCP) to reduce malaria morbidity and mortality by 75% by 2020 from 2012 baseline (National Malaria Control Programme, 2015). In 2014, nationally, the prevalence of fever stood at 13.8% and decline between 2008 and 2014 was about 6%. Table 3 presents prevalence of fever by region. Upper West was the only region that experienced an increase in prevalence of fever from 20.3% to 24.9% between 2008 and 2014. In 2008 it had the third highest prevalence after the Upper East and Northern regions, but had the highest prevalence in 2014. Comparing prevalence of fever to that of the more recent Malaria Indicator Survey (MIS), the prevalence was 43.9% in the Central region, 35.9% in the Western region, 34.7% in the Ashanti region, 23.6% in the Upper West region, 26.6% in the Upper East region, 24.1% in the Northern region whereas 30.2% was at the national level (Ghana Statistical Service, 2016). This means an increase in fever prevalence in 2016 compared with that of 2014 in all regions except in Upper West where it was higher (24.9%) in 2014.

The situation of fever in 2016 means that if malaria interventions (intermittent preventive treatment of malaria in pregnancy (IPTp), insecticide treated bed net (ITN), indoor residual spraying (IRS), artemisinin-based combination therapy (ACT), seasonal malaria chemoprevention) coverages are not increased as with the increasing prevalence of fever and thus possibly malaria, a decline in malaria under-five mortality will be a challenge to achieve within the SDGs years. The malaria vaccine which was introduced this year (June 2019), might make a significant contribution to mortality decline considering the huge burden of malaria in the country (Government of Ghana, 2019). The main strategies to increase access to treatment of malaria are through the Community-based Health Planning Services (CHPS) and Home Based Care (HBC). Artemisinin-based Combination Therapies are the recommended drugs for the treatment of uncomplicated malaria.

2.5.2 Diarrhoea

Diarrhoea is the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). It can be caused by a variety of bacteria, viruses and parasites. Rota virus and *Escherichia coli* are the two most common agents` of diarrhoea in developing countries. Diarrhoea is acquired faeco-orally through contaminated food or drinking-water, or from person-to-person as a result of poor hygiene. It is a major cause of malnutrition as water and electrolytes are lost. Death from diarrhoea is usually as a result of severe dehydration. The malnourished and children with impaired immunity are most at risk of life-threatening diarrhoea. Other signs and symptoms include lethargy or sunken eyes (Gove, 1997).

In 2010, there were 1.731 billion cases of diarrhoea recorded globally, 36 million of these progressed to severe disease and in 2011, 700, 000 cases of diarrhoea died (Walker et al., 2013). Children 0-2 years accounted for 72% of the deaths (Walker et al., 2013). In 2014, diarrhoea prevalence was 11.7% and decline between 2008 and 2014 was 8.1% (Table 3). Diarrhoea can be treated with oral rehydration salt (ORS) and with zinc tablets (Ministry of Health, 2014). Maternal education, presence of sanitary facilities, age of child and number of children under-five years were associated with diarrhoea in Ethiopia, according to Mihrete, Alemie, and Teferra (2014).

2.5.3 Pneumonia

Pneumonia, an acute respiratory infection that affects the lungs, is another important cause of morbidity and mortality among children globally (Rudan et al., 2013) and in Ghana (Ghana Statistical Service (GSS) et al., 2015). In 2010, there were 120 million cases of pneumonia recorded globally among children less than five years old, 14 million of these cases progressed to severe disease and in 2011, 1.3 million cases of children with pneumonia died (Walker et al., 2013). Children 0-2 years accounted for 81% of the deaths (Walker et al., 2013). It is also a leading cause of death among children in Ghana (Ghana Statistical Service (GSS) et al., 2015).

Pneumonia is commonly caused by viruses, bacteria or fungi. These include *Streptococcus pneumoniae*, *Haemophilus influenzae* type b (Hib) and *Respiratory syncytial* virus (Madhi, Levine, Hajjeh, Mansoor, & Cherian, 2008). The infections are generally spread by direct contact with infected people or from spread via air-borne droplets (Kutter, Spronken, Fraaij, Fouchier, & Herfst, 2018). Under-nutrition, indoor air pollution, low birth weight, crowding and lack of measles immunization increase risk of infection (Walker et al., 2013). Prevalence of pneumonia was 3.6% in 2014 and the decline between 2008 and 2014 was 1.9% in Ghana (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Amoxycillin is the drug for treatment (Ghana Health Service, 2015b). Community-based health planning services (CHPS) and home based care (HBC) are the main strategies for increasing access to treatment of pneumonia.

2.5.4 Measles

Measles is another preventable infectious disease of children under-five years. It is an airborne viral disease caused by the measles virus. The disease manifests as a rash. Incubation period is 10-14 days and case fatality is about 30-300/1000 depending on the country (World Health Organization, 2019a). Measles vaccine is an effective means of measles prevention. Prevalence of measles cases and deaths have declined over the years but children in SSA remain mostly affected. Measles vaccination saved 15.6

million lives between 2000 and 2013 translating into a 67% decline in measles cases (United Nations, 2015).

In 2013, about 93% of measles deaths worldwide occurred in SSA (United Nations, 2015). Measles has been targeted for control and elimination but frequent outbreaks due to weak vaccine management is a challenge (United Nations, 2015). There has not been measles mortality in Ghana since 2003, however, outbreaks were reported in 2014 involving 1,039 suspected cases and 121 confirmed positive cases (Ghana Health Service, 2015a). Measles vaccines are given at health facilities, at schools and in communities (Ghana Health Service, 2015a).

2.5.5 Neonatal Tetanus

Tetanus is also a vaccine preventable and treatable infectious disease. It is a non-communicable disease contracted from exposure to the spores of the anaerobic gram positive bacterium *Clostridium tetani.* The organism produces a neurotoxin which is responsible for the disease. *Clostridium tetani* occurs in the environment in soil and in the guts of human and other animals (World Health Organization, 2019b). Its spores could contaminate the birthing environment and subsequently surgical sites and cord leading to maternal or neonatal infection. Neonatal tetanus is therefore more common among individuals residing in unhygienic conditions. Poor health care systems, poverty and illiteracy underlie a high incidence of neonatal tetanus (Messeret et al., 2018).

Neonatal tetanus is tetanus within the first 28 days of life. Incubation period is from 3 to 21days. The umbilical stamp is the portal of entry of the spores (Messeret et al., 2018). Case fatality is high, about 100%. The disease is diagnosed clinically with trismus (lockjaw), dysphagia and neck, shoulders, back, or abdominal muscle stiffness and pain as some signs. Neonatal tetanus can be prevented through maternal vaccination with tetanus toxoid, hygienic birth and clean cord practices. Maternal tetanus injection can effectively lower mortality associated with neonatal tetanus (Abir et al., 2015; Issaka, Agho, & Renzaho, 2016; Weeks, Hill, Getis, & Stow, 2006).

Vaccination is the only way immunity to tetanus is acquired. Total protection from neonatal tetanus is acquired after five doses of tetanus toxoid (Ghana Statistical Service (GSS) et al., 2015). Tetanus antitoxins levels after vaccination have to be optimal for the protection against maternal and neonatal tetanus. No or suboptimal tetanus antitoxins level due to suboptimal tetanus toxoid vaccination can increase the risk of neonatal tetanus and maternal tetanus (Khan, Vandelaer, Yakubu, Raza, & Zulu, 2015). Tetanus can also be treated with antibiotics (World Health Organization, 2019b).

Neonatal tetanus deaths declined globally from 787,000 to 49,000 from 1988 to 2013 attributed to maternal tetanus vaccination. In 2015, neonatal tetanus cases were 1289 while coverage of two or more tetanus toxoid vaccination was 77% in the WHO African region (Messeret et al., 2018). In 1999, neonatal tetanus was targeted for elimination by 2015 by the World Health Organization (WHO) but this was not achieved (Messeret et al., 2018). “The WHO defines Neonatal Tetanus (NT) elimination as the occurrence at the district level of less than 1 case of NT per 1000 live births annually”. Ghana is at the elimination stage of maternal and neonatal tetanus (Ghana Health Service, 2015a).

2.5.6 Neonatal Sepsis

Neonatal infections are preventable and treatable and should not be major contributors to mortality. Quality skilled care is therefore required during birthing to reduce the risk of neonatal infections. Antenatal attendance, hygienic child birth practices, postnatal care and early and exclusive breastfeeding interventions are strategies for prevention and early detection of neonatal infections (Messeret et al., 2018). Also, increased treatment are possible through the training of health personnel on the Integrated Management of Childhood Illness (IMCI) (Lawn, Kerber, Enweronu-Laryea, & Cousens, 2010). Early detection and treatment of syphilis is another intervention targeted at reducing the risk of infection and mortality neonates (Blencowe, Cousens, Kamb, Berman, & Lawn, 2011).

2.5.7 Malnutrition

Under-nutrition, including what occurs during pregnancy and after birth manifest as foetal growth restriction, low birth weight and deficiencies of vitamin A, iodine, iron, zinc, stunting and wasting and anaemia (Boerma, 2018). Breastfeeding, complementary feeding, vitamin A, iodine, Zinc and folic acid supplementation are among the child health nutrition interventions in Ghana. Child under-nutrition could also be a consequence of poor maternal nutrition (Acevedo, García Esteban, Lopez-Ejeda, Gómez, & Marrodán, 2017; Ashorn et al., 2018; Bhutta et al., 2013; Zylbersztejn, Gilbert, Hjern, Wijlaars, & Hardelid, 2018). In Malawi, Ashorn et al. (2018), found that maternal infections, inflammation and nutrition were risk factors of low birth weight. Addressing poverty, poor education, disease and women empowerment could address stunting (Bhutta et al., 2008).

The impact of undernutrition on under-five mortality is huge (Robert 2003, 2008) with all degrees of under nutrition impacting negatively on health (Kramer & Allen, 2015). Tette et al. (2016) found higher odds of death among malnourished children in Ghana. According to Walton and Allen (2011), about a third of under-five deaths in 2008 could be attributed to undernutrition and according to Boerma (2018) under nutrition contributed to 45% of deaths in children younger than five years in 2011 (Collins et al., 2006). An estimated 57.3% of global malaria deaths, 60.7% of diarrhoeal deaths, 52.3% of pneumonia deaths and 44.8% of measles deaths are attributed to under nutrition (Caulfield, de Onis, Blössner, & Black, 2004). It is therefore not surprising that under nutrition follows in the pattern of under-five mortality with south Asian and SSA having the highest burden as poverty has been cited as the cause of undernutrition in developing countries (Petrou & Kupek, 2010). While stunting reduced in all regions of the world between 1990 and 2013, it increased in SSA by one-third (United Nations, 2015). In Uganda, morbidity, sub-optimal infant and young child feeding (IYCF) practices, low consumption of animal-source foods, food insecurity, lack of access to high-quality drinking water, sanitation and hygiene (WASH) facilities and poverty are significant risk factors of stunting (Bukusuba, Kaaya, & Atukwase, 2017). Living with grandparents was also found to be associated with stunting in SSA (Schrijner & Smits, 2018).

2.5.8 Stunting

Inadequate maternal nutrition in pregnancy and child nutrition result in stunting. Thus both maternal and child nutrition are important in reducing the risk of stunting (United Nations, 2015). Stunting directly increases the risk of death, increases susceptibility to infection and affects convalescence and is irreversible. To meet the 2025 target of a

40% reduction in mortality means Ghana has to achieve a stunting prevalence of not more than 11.3%. Prevalence of stunting in 2008 was 28% and in 2014, 18.8% at the national level (Ghana Statistical Service (GSS) et al., 2015).At the regional level, stunting was highest in the Eastern (37.9%), Central (33.7%) and Northern (32.4%) regions but lowest in the Greater Accra (14.2%), Upper West (24.6%) and Brong Ahafo (25.5%) regions in 2008. In 2014, stunting was highest in the Northern (33.1%), Upper West (22.2%) and Central region (22.0%) and lowest in the Greater Accra (10.4%), Upper East (14.4%) and Ashanti (16.1%) (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

2.5.9 Wasting

Wasting is defined as height shorter than normal for an individual's age. Wasting is a manifestation of chronic malnutrition. A study among malnourished children found that wasting was associated with increased risk of mortality (Acevedo et al., 2017). In northern Ghana among preschool children, wasting was higher among males, children who consume less than four food groups and children whose mothers are under-weight (Ali, Saaka, Adams, Kamwininaang, & Abizari, 2017). In Ghana, prevalence of wasting was 8.5% in 2008 and 4.7% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). However, from the World Health Organization, wasting should be at most 5% in 2025, in accordance with the 2025 World Assembly Target (World Health Organization, 2014).

2.5.10 Low Birth Weight

Low birth weight (LBW) is defined as birth weight less than 2.5kg. Low weight-for-age increases the risk of infections such as malaria, diarrhoea, pneumonia and measles. Low birth weight increased the odds of neonatal deaths in Indonesia and Ghana (Abdul-Mumin et al., 2020; Kayode et al., 2014; Titaley et al., 2011). In Ghana, prevalence of low birth weight was 10.0%, in 2008 and 9.5% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Intermittent preventive treatment of malaria and maternal history of low birth weight were associated with low birth weight in Ghana (Klufio, Lassey, Annan, & Wilson, 2001). Lack of iron intake during pregnancy also increased the risk of low birth weight in Ghana (Adam, Ameme, Nortey, Afari, & Kenu, 2019).

Anaemia (haemoglobin concentration less than 11.0g/dl), another manifestation of poor nutrition had prevalence of 66% in Ghana in 2014. Prevalence was highest in the Northern (82.1%), Upper East (73.8%) and Upper West (73.8%) regions but lowest in the Ashanti (53.7%) and Greater Accra (59.6%) regions (Ghana Statistical Service (GSS) et al., 2015). In 2008, prevalence of anaemia at the national level was 77.9% and varied from 88.5% in the Upper East to 88.2% in the Upper West to 62.1% in the Greater Accra region (Ghana Statistical Service (GSS) et al., 2009).

2.5.11 Prematurity

Preterm birth, defined as delivery prior to 37 weeks gestational age, is a worldwide epidemic (Purisch & Gyamfi-Bannerman, 2017). It is a major cause of death among neonates as a direct cause of death as well as a risk factor for low birth weight. Kangaroo mother care (KMC) is one strategy that can be practised in low resource areas to increase survival of preterm babies. The use of topical emollient for preterm demonstrated reduced risk of mortality in low and middle income countries from a systematic review report (Salam, Das, Darmstadt, & Bhutta, 2013).

2.5.12 Injury

This comprises physical injuries, poisoning, burns, drowning, road accident and deaths due to conflicts (Chamberlain et al., 2015; Mamady et al., 2012). Deaths due to injury are a concern in both the developing and developed worlds. While there is decline in mortality due to injury in both developing and the developed world, the burden of injury mortality in the developed world is three time that of the developing world (Huang, Wu, Schwebel, Zhou, & Hu, 2016; D. Scott & Siskind, 2016). Death from injuries is projected to increase in the future (Murray & Lopez, 1997) including in Ghana (Schieber et al., 2012). The burden of injury in Ghana among the general population was 5.4% in 2014 (Ghana Statistical Service, 2014).

In the United States of America, a lower educated mother, younger mothers and those having more than two children were predictors of higher risk of injury (Scholer, Mitchel, & Ray, 1997). In Ghana, higher incidence of injury is common among children living in uncompleted houses (Gyedu et al., 2015). Among children under-five years old in Guinea, falls was the commonest source of injury and boys were at higher risk of injury (Mamady et al., 2012). In the study, cooking outside and having a wardrobe or a cupboard at home reduced odds of injury.

2.5.13 Intrapartum Related Events

Intrapartum Related Events (IPRE) are pathological conditions that can occur before, during or immediately after birth and that result in decrease in the oxygen content in foetal blood. Although preventable, IPREs are a significant contributors to neonatal mortality (Wall et al., 2010). Globally, in 2015, IPRE was the third highest cause of under-five mortality, forming 11.6% of under-five deaths (Liu et al., 2016). Improved antenatal care and skilled attendance can significantly reduce the impact of IPRE on mortality.

2.5.14 Congenital Abnormalities

Congenital abnormalities are another group of conditions that increase the risk of death of children under-five years. The causes of congenital abnormalities range from genetic factors, maternal, nutritional deficiencies and environmental factors. At the global level, the contribution of congenital abnormalities to mortality vary geographically and makes a higher contribution to mortality in high income countries compared to low income countries (Liu et al., 2016). In 2015, congenital abnormalities formed 3.5% of under-five death and 5.1% of neonatal deaths globally (Liu et al., 2016). In eastern Asia, congenital abnormalities replaced pneumonia as the leading cause of under-five mortality between 2000 and 2015 (Liu et al., 2016).

In Ghana, the contribution of congenital abnormalities to U5M is low. In Kintampo in the Brong Ahafo region of Ghana, contribution of congenital abnormalities to neonatal mortality was 2.7% (Edmond et al., 2008). However, among neonatal surgical cases at the Tamale Teaching Hospital in Ghana, congenital abnormalities formed 87% of surgical cases and 96% of neonatal deaths between 2014 and 2017 (Abdul-Mumin et al., 2020). In this study, the major abnormalities were omphalocele, imperforate anus, intestinal obstruction, spina bifida and hydrocephalus.

2.6 Interventions to Address Under-Five Mortality

There exist effective and affordable preventive and treatments services which, when used appropriately, avert the risk of disease, progression of mild disease to severe disease and death (Bhutta et al., 2013). These include vaccination, skilled delivery, clean postnatal care and exclusive breastfeeding. These interventions have contributed significantly to mortality reduction and have been recommended globally for addressing under-five mortality (Das et al., 2013; Geldsetzer et al., 2014). However, the use of these interventions is influenced by individual, household, community and health facility factors (Akseer et al., 2018; Doctor, Nkhana-Salimu, & Abdulsalam-Anibilowo, 2018; Keats et al., 2017).

2.6.1 Community Level Interventions to Address Under-Five Mortality

To address the challenge of access to care in order to reduce mortality, community level interventions have been instituted to increase access to health services and thus coverage of health interventions (Christopher et al., 2011; Freeman et al., 2017). Community level services have been shown to accelerate decline in mortality (Afnan-Holmes et al., 2015) and have been recommended especially for developing countries (Christopher et al., 2011; Das et al., 2013; Geldsetzer et al., 2014). Those aimed at increasing access to treatment are those focused on increasing coverage of treatment and reducing mortality (Christopher et al., 2011). Healthcare at the community level provides services to more people especially the deprived, increases care-seeking (Littrell, Moukam, Libite, Youmba, & Baugh, 2013), increases promptness to treatment and therefore effectiveness of care (Sousa et al., 2012).

Community level health services have also shown to reduce utilization of services at higher level health facilities which could reduce waiting time and pressure on health workers at these higher level facilities and thus improve quality of care (Seidenberg et al., 2012). According to Lal et al. (2015), the use of community health workers led to a

63% decrease in health centre utilization. Also, according to Sousa et al. (2012) universal coverage of intervention targeting the three major diseases (malaria, diarrhoea and pneumonia) with a community delivery approach could reduce annual U5M by over 60% and SSA will be the greatest beneficiary due to the high mortality from these conditions in SSA. Masanja et al. (2008) found rapid decline in U5M during periods of increased coverage of child health interventions. Community based treatment increased care seeking for pneumonia and diarrhoea by 13% and 9% respectively (Das et al., 2013).

In Ghana, the CHPS programme contributed to a decline of under-five mortality of 48/1000 live births from 1995 to 1998 (Awoonor-Williams et al., 2010). Although Ghana is implementing some of these community level interventions aimed at increasing access to care in the other regions, mortality decline is below the expected as Ghana could not achieve the MDGs target and some regions especially the Northern and Upper West regions still record high under-five mortality rates (Ghana Statistical Service (GSS) et al., 2015).

There are reports of low utilization of community level child health interventions (Amouzou et al., 2016; Shaw et al., 2015) and formal health care services for treatment (Gebretsadik, Worku, & Berhane, 2015). Three years after the national scale up of community case management of malaria, less than 1% of sick children in urban areas and 10% in rural areas consulted a community health worker (Druetz et al., 2015) and number of cases of diseases treated by community based agents (CBAs) was found to be below the expected according to D'Acremont and Bosman (2013). In Ethiopia, care-seeking from formal healthcare services for treatment of common childhood illness was about 30% in 2011. In Ghana, utilization of community level services for the treatment of malaria, diarrhoea and pneumonia range from less than 1% to about 31% (Ferrer et al., 2016).

While accessibility and affordability of these interventions are sometimes barriers to their use by caregivers of children, government and other authorities responsible for funding the supply of these interventions equally face financial and other barriers in their supply especially those in poor countries. In Ghana, the Ghana Health Service that delivers these interventions is sometimes challenged financially in the delivery of these interventions resulting in it not meeting coverage level targets (Geldsetzer et al., 2014; Ghana Health Service, 2015a; Okwaraji et al., 2012; Young et al., 2012). The challenges of access to these interventions result in inequity in their distribution, use and coverage.

In Africa, treatment rates of the major killers of children under-five years, diarrhoea with oral rehydration salt, fever with any antimalarial and suspected pneumonia with an antibiotic are generally low. In Ghana, according to the 2014 Ghana Demographic and Health Survey (GDHS), only 52.6%, 55.9% and 44.9% of children under-five years old with symptoms of pneumonia, fever or diarrhoea respectively sought advice or care from health worker or a health facility. About 34.6% and 40.2% of those with malaria received, any Artemisinin-based Combination Therapy (ACT) in urban and rural areas respectively while 26.0% received any ACT on the same day or the next day (Ghana Statistical Service (GSS) et al., 2015). These rates are far below what is needed to achieve a significant decline in mortality. The fact that coverage levels of these interventions are low could mean care is not sought at all for treatment of malaria, diarrhoea and pneumonia (MPD) or is sought from inappropriate sources which could result in inappropriate treatment.

Inequity in child health interventions coverage remains a concern, and thus the call for universal health coverage (Fenn, Kirkwood, Popatia, & Bradley, 2007; Keats et al., 2017; Målqvist, 2015). Coverage of interventions has been shown to differ between rural and urban environments, wealth quintile and by maternal education (Boerma, 2018). Clermont (2017), from a 98 low income countries analysis found that interventions with the most unequal distribution with regard to wealth were health facility services and access to water and sanitation facilities while the most equitably distributed services were those usually distributed at the community level including bed nets, vaccinations and vitamin A supplementation. Also, access to improved sanitation facilities were lower in districts in northern Ghana compared to those in southern Ghana (Arku et al., 2016). In 2016, coverage of Long-Lasting Insecticidal Net (LLIN) was 82% in rural areas but 65% in urban areas (Ghana Statistical Service, 2016). In summary, addressing disparities and thus inequity in coverage of interventions will reduce mortality significantly (Ruhago, Ngalesoni, & Norheim, 2012).

While there is evidence of the efficacy of these interventions and thus their adoption and implementation for child survival improvement, issues of their quality have been raised. The Count Down 2030 collaboration group indicated that, the quality of the services targeted at reducing mortality are poor and might have influenced their impact on mortality reduction during the MDGs period (Countdown to 2030 Collaboration, 2018). According to Kruk et al. (2018), about 5 million excess deaths including neonatal deaths recorded in 2016 in 137 low and middle income countries were attributable to poor quality of care. In this study, neonatal deaths ranked second in deaths from poor quality of care.

Beyond the effect of poor quality of care on mortality, some interventions have been positively correlated with child mortality. Evidence from the literature have found vaccines associated with higher mortality (Aaby, Mogensen, Rodrigues, & Benn, 2018; Aaby, Ravn, & Benn, 2016; Welaga et al., 2012). A systematic review by Higgins et al. (2016) found a higher risk of death among vaccinated children compared to unvaccinated children. Diptheria, pertusis, tetanus (DPT) vaccine was found to be associated with higher odds of death among girls (Aaby, Ravn, Fisker, Rodrigues, & Benn, 2016). Diptheria, pertusis, tetanus was also associated with higher mortality according to Mogensen, Andersen, Rodrigues, Benn, and Aaby (2017). Malaria vaccine was also found to be associated with increased mortality among girls (Klein, Shann, Moss, Benn, & Aaby, 2016). While improved nutrition has great health benefits, iron supplementation has been associated with increased risk of some infections and mortality (Oppenheimer, 2001). In Zanzibar, A combination of iron and folic acid reduced risk of neonatal mortality while iron alone had no effect on neonatal mortality in 19 SSA countries (Titaley, Dibley, Roberts, & Agho, 2010). A trial involving iron and folic supplementation to preschool children in Zanzibar was stopped due to increased risk of mortality among the intervention group (Sazawal et al., 2006). Below are some interventions targeted at reducing under-five mortality in Ghana.

2.6.2 Vaccines

Vaccines are biologically derived substances that provoke a protective immune response in a susceptible host. These could be live attenuated organisms, killed organisms or sub-units, toxoids, polysaccharides, recombinant DNA sub-units or nuclei acid plasmids. Vaccines have contributed enormously to the reduction of childhood diseases and thus child mortality globally over the years (Ngabo et al., 2016; Shifa et al., 2018). Vaccinations led to the eradication of the smallpox disease. Vaccines protect individuals from getting the disease it is formulated against, reduces prevalence of the disease and can interrupt the transmission of the disease. At the level of herd immunity, even individuals who have not received the vaccine become protected from contracting the disease.

In Burkina Faso, Millogo, Doamba, Sié, Utzinger, and Vounatsou (2019) documented improved child survival with measles, and DPT vaccines as well as the combination of all vaccines. However, vaccine preventable diseases are still an important cause of death in some settings. Some factors affect the protective effect of vaccine when introduced into a population. This includes cold chain management which affects the potency of vaccines and therefore their effectiveness and impact (Mupere et al., 2006). Vaccine aimed at addressing child morbidity and mortality in Ghana include: pentavalent (diphtheria, pertussis, tetanus, hepatitis B and Haemophilus influenza type B.), tetanus toxoid, measles, rota virus, pneumococcal, polio, hepatitis B. Diptheria, pertusis, tetanus was replaced with pentavalent in 2002. Rota virus and pneumococcal vaccines were the last set of vaccines to be introduced in 2012 (Ghana Statistical Service (GSS) et al., 2015; Yawson et al., 2017). Malaria vaccine introduced in 2019 as part of a phase one trial in Ghana, Kenya and Malawi (Government of Ghana, 2019). In Ghana, it is being piloted in 33 district of the Bono East, Bono, Ahafo, Central, Volta and Oti regions of Ghana. It has the potential to prevent 50,000 of malaria cases and 750 malaria deaths in the intervention areas (Government of Ghana, 2019).

Vaccines are among the most equitably distributed interventions in poor and hard to reach areas (Clermont, 2017). Coverages of DPT vaccine, Hib vaccine, Measles vaccine, pneumococcal, rota virus vaccine were over 80% in 2014 (Ghana Statistical Service (GSS) et al., 2015). Protection from neonatal tetanus was 71.9% in 2008, 78% in 2014 (Ghana Statistical Service (GSS) et al., 2015) and 77% in 2017 (Ghana Statistical Service (GSS) et al., 2018). Asuman, Ackah, and Enemark (2018) documented that complete immunizations is higher among rural dwellers than urban dwellers in Ghana. Also, from the 2014 Ghana Health Service report, the Greater Accra region had the most unimmunized children (Ghana Health Service, 2015a). This could be due to improved access to vaccination services in rural areas due to the implementation of the CHPS.

Vaccines whose impacts were assessed in this study are those which impact on mortality and for which data is available in the DHS data set. These include: pentavalent, neonatal tetanus protection, measles, rota virus vaccine and pneumococcal vaccines. Maternal tetanus toxoid vaccine protects neonates from neonatal tetanus. A total of five doses of tetanus toxoid vaccines are required for full tetanus protection. Protection from neonatal tetanus has been shown to be associated with reduced mortality (Abir et al., 2015; Ghimire et al., 2019; Weeks et al., 2006) but found higher odds of death with two or more does of tetanus vaccine compared to one while (Dwomoh et al., 2019) found no effect of tetanus vaccination on infant and under-five mortality. Other vaccines include pentavalent vaccine prevent diphtheria, pertussis, tetanus, hepatitis B and influenza type B, measles vaccine which prevents measles, rota virus prevents diarrhoea while pneumococcal vaccines prevents pneumonia. Pentavalent and pneumococcal vaccine are given as three doses at 6, 10 and 14 weeks, measles as two doses at nine and eighteen months (before 2004 was one dose at 9 months), while the rota virus vaccine is given as two doses for 6 and 10 weeks. In 2013, the nine month measles was replaced with measles-rubella vaccine (Ghana Statistical Service (GSS) et al., 2015).

Diptheria, pertusis, tetanus vaccination was associated with reduced hazard of death in Burkina Faso (Millogo et al., 2019).The national coverage target for all vaccines is 90% and most vaccines had coverage levels above 80% in 2008 and 2014 (Ghana Health Service, 2015a). Vaccines are delivered through the Expanded Programme on Immunization (EPI) established in 1978 in Ghana (Yawson et al., 2017). Global Alliance for Vaccines and Immunization (GAVI) has been the main financial supporter of the vaccination programme in Ghana (Ghana Health Service, 2015a).

2.6.3 Child Nutrition Interventions

Apart from vaccines, good nutrition plays an important role in child survival. Such interventions include: iron, folic acids and vitamin A supplementation, breastfeeding and complementary feeding (Bhutta et al., 2008; Zere, Kirigia, Duale, & Akazili, 2012). Iron and folic acids prevent anaemia in pregnant women which can result in preterm and small for gestational age babies. In addition, folic acid prevents congenital abnormalities like neural tube defects (Lawn et al., 2010). Zakaria et al. (2017) found 28.9% of child deaths due to congenital malformations with neural tube defect contributing (5.8%) of these deaths.

After delivery, children are supposed to start breastfeeding within one hour, be breastfed exclusively for six months and breastfeeding should continue until the child is two years. Lack of breastfeeding increased odds of deaths of neonates according to Kayode et al. (2014) in Ghana. Exclusive breastfeeding reduced time to death of children under-five years in Burkina Faso (Millogo et al., 2019). Edmond et al. (2006) also found higher risk of death of neonates with delayed initiation of breastfeeding in Ghana. Shifa et al. (2018) also observed the same in Ethiopia. In Bangladesh, delayed initiation of breastfeeding increased odds of severe disease among new-borns (Abdullah, Hort, Butu, & Simpson, 2016; Raihana et al., 2019). Early initiation of breastfeeding reduced hazards rate in Uganda (Nambuusi et al., 2019) and in Indonesia (Berkat & Sutan, 2014) among low birth weight babies. After six months of exclusive breastfeeding, complementary feeding is supposed to provide a balanced diet each day for each meal. Complementary feeding is consuming four or more food groups a day (Ghana Statistical Service (GSS) et al., 2015).

Vitamin A and zinc are two of the nutritional interventions delivered in Ghana (Zere et al., 2012). Vitamin A is given at six months and for every six months for up to two years. It promotes growth and eyesight development. Vitamin A also plays a role in reducing diarrhoea mortality. Shifa et al. (2018) found reduced odds of death with vitamin A supplementation in Ethiopia, Millogo et al. (2019) in Rwanda and Nambuusi et al. (2019) in Uganda and Florey et al. (2017) in Malawi. Zinc is associated with reduced mortality due to diarrhoea and respiratory infections and also reduces stunting risk.

While vaccines are delivered to caregivers of children by the health system with minimal cost, appropriate feeding of children can be a challenge. Ensuring exclusive breastfeeding up to six months (Waterhouse, Hill, & Hinde, 2017) and complementary feeding that provides a balanced diet every day after the six months can pose a challenge. While poverty can reduce access to food, rich caregivers can also be too busy to exclusively breastfeed and provide a balanced diet for their children. Apart from the influence of poverty on good nutrition, knowledge of what constitute a balance diet and the ability and independence to create one can also pose a challenge to care givers of children (Mwangome, Prentice, Plugge, & Nweneka, 2010).

Exclusive breastfeeding prevalence decreased between 2008 and 2014 in Ghana. While exclusive breastfeeding among children less than one month and from 1-5 months were 84.3% and 60.6% respectively in 2008, these reduced to 65.6% and 54.3% respectively in 2014. Complementary feeding also declined from 47.3% in 2008 to 28.1% in 2014. The reduction in breastfeeding and complementary feeding is a cause for worry considering the importance of nutrition and especially breastfeeding to child survival (Bahl et al., 2005). Community-based Management of Acute Malnutrition (CMAM) is one strategy to addressing malnutrition issues in Ghana (Ghana Health Service, 2015a).

2.6.4 Other Malaria Control Interventions

Malaria remains a threat to child survival in Ghana. It affects all stages of live from pregnancy and thus there are several interventions targeting its effect. These include intermittent preventive treatment of malaria in pregnancy (IPTp), insecticide treated ned net (ITN), indoor residual spraying (IRS), artemisinin-based combination therapy (ACTs), seasonal malaria chemoprevention (SMC) and malaria vaccine. It is the goal of the Ghana National Malaria Control Programme (NMCP) to reduce malaria morbidity and mortality by 75% by 2020 using 2012 as baseline (National Malaria Control Programme, 2015)

Insecticide treated bed net is the most common malaria prevention tool in Ghana. It reduces human-mosquito contacts and thus the risk of infection. Long lasting insecticide nets (LLINs) are the preferred types of net as they do not require retreatment. ITNs have individual as well as communal protective effect (Binka, Indome, & Smith, 1998). In a community based trial in northern Ghana, bed net use was associated with a 17% reduction in the all-cause mortality rate (Binka et al., 1996). In Ghana, bed nets reduced risk of malaria deaths by 29% (Nakamura et al., 2011). Dwomoh et al. (2019) also documented reduction in neonatal and under-five mortality with bed net use while Millogo et al. (2019) and Afoakwah, Nunoo, and Ando (2015) reported lower odds of death with treated bed net use among children under-five year. They seem to be replacing vaccines as the most impactful intervention in mortality reduction in Ghana (Akachi & Atun, 2011). Insecticide treated net ownership has been documented to be responsible for the decline in mortality in Kenya (Demombynes & Trommlerová, 2016).

Insecticide treated net coverage was scaled-up nationally in 2004 (Awine, Malm, Bart-Plange, & Silal, 2017) Coverage level of household ownership of a least one ITN increased from 45.5% in 2008 to 69.6% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009) and 73.9% in 2016 (Ghana Statistical Service, 2016). Bed nets are distributed at ANC, child welfare clinics, in schools and communities. The target of ITN coverage in Ghana is universal coverage defined as one LLIN per every two people in a household. This stood at 51% in 2016 from the MIS report. GHS seeks to have 80% of the population covered by malaria prevention intervention by 2020 (National Malaria Control Programme, 2015).

Intermittent Preventive Treatment of Malaria in Pregnancy, is a malaria preventive treatment intervention. The treatment is done using the drug Sulphadoxine-pyrimethamine (SP). Sulphadoxine-pyrimethamine is expected to reduce malaria incidence in pregnant women and consequently, the effect of malaria on the foetus. It was given as two doses to pregnant women after the first trimester and one month between the doses but this has been revised to three or more doses (Ghana Statistical Service, 2016). Intermittent Preventive Treatment of Malaria in Pregnancy coverage increased from 45.5% in 2008 to 67.5% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009) and 78% in 2016 (Ghana Statistical Service, 2016). Intermittent Preventive Treatment of Malaria in Pregnancy was found to be associated with reduced hazards rate under-five mortality in Uganda (Nambuusi et al., 2019). It was associated with reduced odds of stillbirth in Nigeria (Orobaton et al., 2016).

Indoor residual spraying also reduces the risk of malaria infection and thus malaria morbidity and mortality among all malaria susceptible individuals including pregnant women. It involves spraying the interior of walls of homes so that mosquitoes that settle on the sprayed walls die. AngloGold Ashanti, and the USAID-President's Malaria Initiative have been carrying out IRS, and it has been ongoing since 2005 (Awine et al., 2017). Coverage level of IRS in 2014 was.9.7% (Ghana Statistical Service (GSS) et al., 2015).

Malaria is treated with ACTs. ACTs were introduced in 2004 to replace chloroquine in Ghana. All three ACTs, Artesunate-Amodiaquine (AS-AQ), Artemether-Lumefantrine (AL) Dihydroartemisinin-Piperaquine (DHAP) drugs are safe for use in children except

Artemether-Lumefantrine for children below 6months. Severe malaria is treated with artesunate (rectal or intramuscular) or intramuscular quinine (Ministry of Health, 2014). Treatment is for a period of three days. Ghana Health Service recommends 100% treatment of malaria cases with quality assured ACTs (National Malaria Control Programme, 2015) . Funding for malaria control include funds from the government, Global Fund, PMI/USAID, UNICEF, WHO and DFID (National Malaria Control Programme, 2015). Coverage of ACTs use was 26.2% in 2014 (Ghana Statistical Service (GSS) et al., 2015). In Ethiopia, ACTs caused only a 2% decline in under-five mortality (Doherty et al., 2016). ACT use as been found to be associated with increased hazard rate of under-five mortality in Uganda (Nambuusi et al., 2019).

2.6.5 Treatment of Diarrhoea and Pneumonia

Diarrhoea and pneumonia are two other conditions for which treatment is crucial for survival. Unfortunately, treatment coverage levels for these conditions are usually low in Africa (Afnan-Holmes et al., 2015). The full benefits of these effective treatment interventions might therefore not be realised due to their low coverage and thus low impact. Diarrhoea is treated with oral rehydration salts (ORS) and zinc while dysentery and pneumonia are treated with antibiotics. The Ghana Health Service recommends 100% treatment of diarrhoea and pneumonia (National Malaria Control Programme, 2015). Despite this, coverage of treatment of diarrhoea with ORS was only 48.6% in 2014 while care seeking for suspected pneumonia was 52.6% (Ghana Statistical Service (GSS) et al., 2015). In Malawi, treatment of malaria, diarrhoea and pneumonia collectively contributed to a 23% reduction in mortality as reported by Kanyuka et al. (2016). In Uganda, ORS use reduced hazards of under-five mortality rate (Nambuusi et al., 2019).

2.6.6 Antenatal Care Visits

Antenatal visits are avenues for mothers to be examined and educated on pregnancy and pregnancy related issues. More importantly, mothers become educated on the complications in pregnancy and actions to take to prevent adverse events. Various micronutrient supplements and tetanus vaccines are also given at the ANC. In Ghana, four or more ANC visits are recommended(Ghana Statistical Service (GSS) et al., 2018). ANC services are among the equitably distributed healthcare services (Weeks et al., 2006). Health insurance membership increased chances of ANC visits in Ghana (Owoo & Lambon-Quayefio, 2013). Coverage was 78.2% in 2008, 87.3% 2014 (Ghana Statistical Service (GSS) et al., 2015) and 89% in 2017 (Ghana Statistical Service (GSS) et al., 2018) . In Bangladesh, Akter, Dawson, and Sibbritt (2017) found that ANC visits reduced mortality. A higher number of ANC visits was found to be associated with reduced under-five mortality in Bangladesh (Gruebner et al., 2017) and in Burkina Faso (Millogo et al., 2019). Also in Ghana, Lambon-Quayefio and Owoo (2014), (Kayode et al., 2014) and (Dwomoh et al., 2019) found that ANC visits reduced risk of under-five mortality. Also in Indonesia, ANC attendance was protective against early neonatal deaths (Titaley et al., 2011) and across countries in SSA (Tekelab, Chojenta, Smith, & Loxton, 2019).

2.6.7 Health Facility and Skilled Delivery

Skilled care before, during and after delivery has been recommended for improving child survival especially in improving neonatal mortality. Skilled care has the potential to reduce deaths due to preterm, intrapartum, and infection-related deaths which are the major causes of neonatal deaths. Skilled delivery ensures that infections are prevented by appropriate practices and complicated pregnancies, preterm and low birth weight children receive the necessary and appropriate care (Titaley et al., 2011). Care for preterm babies is one of the most pressing issues affecting their survival because of lack of facilities for their care in Ghana as in other developing countries (Okeke & Chari, 2014).

Skilled delivery services are about the least equitably distributed interventions (Clermont, 2017). Coverage of skilled delivery was 58.7% in 2008, 73.3% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009) and 79% in 2017 (Ghana Statistical Service (GSS) et al., 2018). Lack of facilities for their care results in poor quality of care. While improved child survival have been documented with health facility in Indonesia (Abdullah et al., 2016) and skilled care in Burkina Faso (Millogo et al., 2019) and Uganda (Nambuusi et al., 2019), and Ghana (Afoakwah et al., 2015) the quality of care at birth, including health facility and skilled delivery have been raised (Afnan-Holmes et al., 2015; Manu et al., 2014). In Ghana Nesbitt et al. (2013) found low quality of health facility care in Kintampo. While coverage of health facility care was 68%, quality health facility care was only 18% in Kintampo (Nesbitt et al., 2013).

Poor quality of care could account for the negative evidence of the influence of skilled care on mortality (Vesel et al., 2013). In Malawi, a ban on delivery outside formal health facilities saw an increase in heath facility delivery but not a decline in neonatal mortality (Godlonton & Okeke, 2016). Unexpectedly, home delivery reduced odds of neonatal deaths relative to health facility delivery with and without caesarean section in Bangladesh (Abir et al., 2015). Muzyamba, Groot, Pavlova, Rud, and Tomini (2018), documented small differences in survival of children delivered by professional maternal care givers and those delivered by traditional birth attendance. Also in Ghana, Lambon-Quayefio and Owoo (2014) found no association between skilled delivery and neonatal mortality in 2008, while Dedefo, Oljira, and Assefa (2016) in Ethiopia found that children delivered at health centres had increased chances of death compared to those delivered at home. Also in Ethiopia where the MDG was achieved, antenatal care and skilled delivery coverage levels in 2014 were 32% and 15% respectively which could be considered very low (Doherty et al., 2016). Skilled delivery contributed to a 7% mortality reduction in Malawi according to Kanyuka et al. (2016).

In Ghana, among women who delivered at home, 79% delivered on a covered surface, 79% of birth attendance washed their hands, 98% used a new blade to cut the cord, 90% tied the cord with a new thread and 8% practiced dry cord care (Hill et al., 2010). Also in Ghana, Moyer et al. (2012) found that although most community members (mothers, household heads and grandmothers) understood the need for clean birth practices, these where not generally practised. Also in Ghana, maternal education, antenatal visits and National Health Insurance membership were associated with increased utilization of skilled care (Gudu & Addo, 2017).

Related to health facility delivery is type of delivery. While Ezeh et al. (2015) found increased risk of death among children born through caesarean section in Nigeria, Titaley et al. (2011) in Indonesia found not association between delivery type and early neonatal mortality. Kangaroo mother care reduced odds of death of low birth weight babies (Abdullah et al., 2016).

2.6.8 Clean Postnatal Care

Sepsis is a major cause of neonatal mortality and cord care influences the incidence of neonatal sepsis. Therefore clean birth and postnatal care practices are recommended for reducing infection and neonatal mortality (Seward et al., 2012). It is recommended that women after delivery have postnatal care within 48 hours. This will ensure that infections are prevented and or identified early. Clean postnatal care can significantly contribute to the elimination of neonatal tetanus which is a major contributor to neonatal mortality (Messeret et al., 2018).

Despite this recommendation, coverage of postnatal care visits is low in some countries. (Magge, Chilengi, Jackson, Wagenaar, & Kante, 2017) documented PNC coverage of 30.3% in Tanzania, 5.4% in Zambia and 17.2% in Rwanda. In Ethiopia, Limenih, Endale, and Dachew (2016) reported a postnatal care visit of less in 25%. Mohan et al. (2015) also reported clean postnatal care use of 33.5% in Tanzania. However in Ghana, from the 2017 Ghana Maternal Health Survey, 81% of babies received clean postnatal care within two days after delivery (Ghana Statistical Service (GSS) et al., 2018). This was a significant increased over the coverage levels in 2008 (6.4%) and 2014 (22.8%) (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

Several factors affect postnatal care service use (Aseweh Abor, Abekah-Nkrumah, Sakyi, Adjasi, & Abor, 2011). On factors affecting the patronage of clean postnatal services, Mohan et al. (2015) in Tanzania found that a minimum of primary education, caesarean for forceps delivery and advice from community worker were positively correlated with postnatal care service use. Coverage of PNC was less than 25%

however. Contrary to this, delivery at a health facility, health centre or dispensary reduced odds of postnatal care use. In Ethiopia, Limenih et al. (2016) also found that awareness of delivery complications, institutional delivery, caesarean delivery and complications during delivery promoted postnatal care use. In this study postnatal care was 33.5%. Also in Nigeria, higher education and health facility delivery favour the use of postnatal care services. In Zambia, maternal education, four plus ANC visits and exposure to mass media increased odds of use of postnatal care services (Bwalya, Mulenga, & Mulenga, 2017). In Bangladesh, while Akter et al. (2017) found that postnatal care had no effect on mortality but Kayode et al. (2014) found reduced adds of death among neonates who attended postnatal care in Ghana, (Millogo et al., 2019) in Burkina Faso. (Shifa et al., 2018) also found increased odds of death with lack of clean postnatal care in Ethiopia. Delayed postnatal care was correlated with increased chances of death in study involving 27 African countries (Issaka et al., 2016). Clean postnatal care for babies was associated with lower hazard of death in Burkina Faso (Millogo et al., 2019).

2.6.9 Contraceptive Prevalence and High-Risk Fertility Behaviours

High fertility rates and low contraceptive prevalence have been cited as reasons for the poor child survival in SSA and in low and middle income countries (Kozuki & Walker, 2013; Murray et al., 2007). High-risk fertility behaviours comprise short birth intervals (birth in less than 24 months of previous birth), maternal age less than 18 years or greater than 34 years and birth order greater than three (Ghana Statistical Service (GSS) et al., 2015).

Low access to contraceptives can reduce birth spacing and thus result in shorter birth intervals and poor nutritional outcomes for children (Rutstein, 2005). Shorter birth interval is associated with small for gestational age, preterm and increased child mortality (Kozuki et al., 2013). Therefore, increased use of contraceptives can have a significant impact on under-five mortality (Ghimire et al., 2019; Tam & Pearson, 2017). Contraceptive use was associated with reduced risk of neonatal mortality in Bangladesh according to Abir et al. (2015) and under-five mortality in Nepal (Ghimire et al., 2019). Other studies have also demonstrated no effect of family planning use on under-five mortality (Nambuusi et al., 2019). Reduction in fertility rate in the Upper East region of Ghana contributed to a decline in child mortality (Awoonor-Williams et al., 2010). Northern region which has the highest mortality rate in Ghana also has the highest fertility rate and the lowest contraceptive prevalence rate of 18.5% in 2017 compared to a national coverage of 30.8% in 2017(Ghana Statistical Service (GSS) et al., 2018)

2.6.10 Water and Sanitation

Access to water and sanitation facilities play an important role on human survival and especially for children less than five years (Bawankule, Singh, Kumar, & Pedgaonkar, 2017; Ferriman, 2007). They are significant contributors to the risk of diseases and mortality as most infectious diseases which still form a high proportion of causes of morbidity and mortality in SSA can be prevented with improved access to water and sanitation facilities (Corsi & Subramanian, 2017; Fuente, Allaire, Jeuland, & Whittington, 2020). Hinman (2017) in Baltimore, USA, found clusters of high mortality in African America neighbourhoods in 1880 which disappeared in subsequent years attributed to improved sanitation. Improved sanitation was found to be associated with reduced under-five mortality in Bangladesh (Gruebner et al., 2017) while improve access to water and sanitation associated with reduced hazard rates in Uganda (Nambuusi et al., 2019). Improved water source however was associated with higher hazards rates among children under-five years in Malawi (Florey et al., 2017). The same had no effect in Ghana (Dwomoh et al., 2019).

Globally over the years, there have been calls for governments to improve on sanitation conditions as a means of morbidity and mortality prevention (Brown, Cairncross, & Ensink, 2013; Lavy, Strauss, Thomas, & de Vreyer, 1996; McArthur et al., 2018). Unfortunately, political commitment to increasing coverage levels of water and sanitation facilities has been a challenge, despite knowledge of their health and economic benefits. Rural dwellers and the poor disproportionately live under unhygienic condition. At the personal level, sanitary disposal of stool of children was higher among the rich, with mothers with higher levels of education (Azage & Haile, 2015). Water and sanitation coverage levels are among the lowest among all interventions with the potential to reducing under-five mortality in Ghana. In 2016, however, from the malaria indicator survey (MIS), water connection in the home and improved toilet facilities increased from about 10% to 40% and 13% to 15% respectively, however, access to an improved source of drinking water reduced from 70% to 50% (Ghana Statistical Service, 2016).

2.7 Coverage of Interventions among all Children Under-Five Years in Ghana

At the national level, coverage levels of child vaccines were among the highest, over 80% both in 2008 and 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Apart from pneumococcal and rota virus vaccines that did not exist at baseline and therefore have coverages change of over 80%, ITN/IRS and IPTp had the highest coverage increase of 29% and 22% respectively in 2014. The highest decline in coverage level occurred with complementary feeding, 18.8%. Exclusive breastfeeding among children less than one-month old was 84.3% in 2008 and declined by 5.9% in 2014. Exclusive breastfeeding also declined by 10.6% between 2008 and 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

At the regional level in 2008, diphtheria, pertussis and tetanus (DPT), *Haemophilus influenzae* type B vaccine (Hib), measles vaccine, pneumococcal and rota virus vaccines were over 80% in coverage in all regions except in the Northern region where DPT and Hib were both 75.1% (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Again in 2014, coverages were about 80% in all regions except in the Northern and Upper East regions where coverage of measles vaccine was 79.4% in the Northern region and pneumococcal vaccine was 78.6% in the Upper East region. Apart from vaccines with coverage level of over 80%, health facility and skilled delivery in the Greater Accra region also had coverage levels of over 80% in 2008. Again in 2014, interventions with coverages about 80% were ITN/IRS in the Upper East region and health facility and skilled delivery coverage in the Greater Accra region of Ghana. Generally, zinc for diarrhea, water connection to the home, ACTs for malaria, clean postnatal care and improved sanitation were the lowest in prevalence in 2008 while water connection, improved sanitation and zinc for treatment of diarrhea had the lowest coverage levels in all regions in 2014.

Considering changes in coverage levels between the periods of evaluation, apart from the introduction of pneumococcal and rota virus vaccines that resulted in a very high increase in their coverage levels, other interventions with high increase in coverage were antibiotic for dysentery (77.3%) and clean postnatal care in the Upper East region (52.2%), iron supplementation in the Upper West (52%) and Northern regions (42.1%) and IPT in the Upper East region (41.7%) (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Hygienic disposal of stool (33.0%) and complementary feeding (30.2%) declined the most and these occurred in the Upper East region. Generally, coverage of water and sanitation interventions experienced low improvement between 2008 and 2014 and the situation was even worse in the then Northern region. Improved sanitation and improved water access increased nationally by 2.4% and 8% while water connection in the home reduced by 4.5% (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

On breastfeeding, in 2008, there was 100% exclusive breastfeeding among children less than one month in the Upper West region. The rest of the regions had rates between 82% and 90%. Exclusive breastfeeding among children one (1) to five (5) months old was below 85% in all regions while early initiation of breastfeeding rates were below 70% in all regions. All children had a level of breastfeeding from birth to five months. In 2014, Upper West and Upper East regions recorded 100% exclusive breastfeeding among children less than one month. Greater Accra recorded about 90% while the Northern region recorded below 80%. Among children 1-5 months, exclusive breastfeeding ranged from about 80% in the Upper West region to 52% in the Northern region and about 50% nationally. Early initiation of breastfeeding rates were below 70% in all regions and nationally. Some children 1-5 months old (4.0% in the Greater Accra region in 2014) were not being breastfed at all in all regions except in the

Northern region (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

2.8 Impact of Interventions on Under-Five Mortality

Increasing coverage levels of current interventions have been advocated to accelerate decline in child mortality, and evidence of the impact of these interventions are numerous. Black et al. (2016) reported that 849,000 stillbirths, 1, 498,000 neonatal deaths and 1,515,000 additional child deaths will be prevented globally with targeted increase in maternal and child health interventions. In a systematic review by Munos, Walker, and Black (2010), treatment with ORS could reduce diarrhoea mortality by about 93%. Zinc could also reduce diarrhoea mortality by 23% (Walker & Black, 2010). LiST estimates in Ghana in 2010 showed that a minimum set of five interventions namely treatment of diarrhoea, malaria and pneumonia, use of insecticides treated nets and improved sanitation if scaled up to 60% could result in a 20% decline in under-five mortality in five years (Bryce et al., 2010).

Also according to Chou, Friberg, Christian, Walker, and Perry (2017), African countries will benefit the most if current coverage of interventions were scaled up to 90% and nutritional interventions during pregnancy, treatment of malaria with artemisinin compounds, oral rehydration solution for childhood diarrhoea, hand washing with soap and oral antibiotics for pneumonia will be the most impactful. However, globally, Central and West African countries have some of the lowest coverage levels of interventions except for coverage of immunizations and continued breastfeeding among children 12-15 months which are usually about 80% (Boerma, 2018).

During the MDGs period, statistical modelling attributed the greatest decline in mortality to that due to vaccinations and also those due to treatment of malaria, diarrhoea and pneumonia (Boerma, 2018). Globally, measles immunization saved 15.6 million deaths between 2000 and 2013 (United Nations, 2015). Lives saved tool estimates in Malawi showed that an annual decline of under-five and neonatal mortality rates of 5.4% and 3.3% respectively between 1990 and 2013 was achieved due to interventions such as: treatment of diarrhoea, pneumonia and malaria (23%), insecticide-treated bed nets (20%), vaccines (17%), reductions in wasting (11%) and stunting (9%), facility birth care (7%) and prevention and treatment of HIV (7%) (Kanyuka et al., 2016). In this study most of the interventions had coverage levels increasing by 20 percentage points (four plus ANC visits, 54% to 46%, IPTp, 28% to 59%, neonatal tetanus protection, 57% to 62%, facility delivery 53% to 90%, skilled delivery 54% to 89%, early initiation of breastfeeding 71% to 74%, exclusive breastfeeding among children 0-6 months 44% to 70%, DPT3, 84% to 93%, measles 83% to 92%, Hib 30% to 93%, pneumococcal 0% to 97%, vitamin A 76% to 86%, household ITN/IRS, 5% to 80%, first line treatment of malaria, 19% to 31%, ORS 48% to 64%, care seeking for pneumonia 27% to 62%, improved water 67% to 87% and improved sanitation 83% to 95%) and contributed to saving 280,000 lives between 2000 and 2013. Malawi therefore achieved the MDG4 in 2013 with a total decline in mortality from 247 to 71 deaths per 1000 livebirths (Kanyuka et al., 2016).

Niger also achieved the MDG4 with a drop in under-five mortality from 226 to 128 deaths per 1000 live births, translating into an annual decline of 5.1% and with a total of 59 000 lives saved between 1998 and 2009 (Amouzou et al., 2012). Introduction of insecticide-treated bed nets (25%), improvements in nutritional status (19%), vitamin

A supplementation (9%); treatment of diarrhoea with oral rehydration salts and zinc, care seeking for fever, malaria, or childhood pneumonia (22%) and vaccinations (11%) were responsible for this decline (Amouzou et al., 2012). Still in Niger, about 26, 000 lives of children under-five years were saved mostly due to reduction in stunting prevalence (27%), increase ORS use (14%), use of Hib vaccine (14%) and breastfeeding (11%) in 2012 (Besada et al., 2016).

Ethiopia achieved the MDG with a 69% decline in mortality from 205 per 1000 live births in 1990 to 64 per 1000 live births in 2013 with 50% of 469 000 lives saved between 2000 and 2011 was attributed to improvement in nutrition status of children (Ruducha et al., 2017). Coverage of other interventions were low except for vaccinations that increased to 60% and family planning that also increased to 63% (Ruducha et al., 2017). Also in Ethiopia, Doherty et al. (2016) reported that 60,700 child deaths were averted in 2011, as a result of reduction in wasting rates (18%), stunting rates (13%) and improvement in water, sanitation and hygiene (WASH) interventions (13%).

In Tanzania, a 39% reduction in mortality between 1990 and 2014 was documented to be largely due to immunization and bed net use (Afnan-Holmes et al., 2015). Haemophilus influenza type B vaccine and bed net use saved 9,100 (27% increase in coverage) and 8,000 (24% increase in coverage) lives respectively in 2000 relative to 2012. Tanzania is one of the few countries in SSA projected to achieve the SDGs target on under-five and neonatal mortality (Afnan-Holmes et al., 2015). Additionally, improvements in breastfeeding and complementary feeding led to 2,400 additional lives saved in neonates and children still in Tanzania (Afnan-Holmes et al., 2015).

Additionally, economic growth was also cited to have contributed to mortality reduction in Tanzania. Also, Ghana experienced a 23.1% decrease in mortality between 2003 and 2008 with about 10% of this reduction attributed to bed net use and 1.6% due to increases birth interval according to Nakamura et al. (2011). Black et al. (2016) also documented that provision of contraceptives; labour and delivery management, care of preterm births; treatment of pneumonia, diarrhoea, malaria and neonatal sepsis and management of severe acute malnutrition would make the greatest impact on mortality if interventions targeting them were scaled up to 90% from 2015 levels in low and middle income countries.

In summary, relatively, treatment of malaria, diarrhoea and pneumonia (Boerma, 2018), insecticide-treated bed nets (Amouzou et al., 2012), vaccines (United Nations, 2015), reductions in wasting and stunting (Kanyuka et al., 2016) made the greatest contribution to mortality decline mostly during the MDGs period. Breastfeeding (Besada et al., 2016), vitamin A supplementation (Amouzou et al., 2012), improvement in water and sanitation (Doherty et al., 2016), health facility delivery (Kanyuka et al., 2016) and skilled delivery also made impact in some countries (Doherty et al., 2016). Skilled delivery, reduction in stunting, water connection in the home and improved sanitation (Tam, Huicho, Huayanay-Espinoza, & Restrepo-Méndez, 2016), increase in contraceptive prevalence Black et al. (2016) will make the most impact, if their coverage levels are increased. In addition to increasing coverage of current interventions, improving their quality (Countdown to 2030 Collaboration, 2018), introduction of new technologies are been advocated to accelerate mortality decline. According to Herrick et al. (2017), small-scale use of chlorine in water could reduce under-five mortality.

2.9 Socio-Economic Determinants of Under-Five Mortality

Several factors operating at the individual, household and community levels influence under-five mortality (McKinnon, Harper, Kaufman, & Bergevin, 2014). The extent of the influence of the various factors vary depending on the context and thus inconsistent results of their association with mortality in the literature (Kazembe, Clarke, & Kandala, 2012). This makes the role of context in understanding child survival important.

2.9.1 Child Factors

On child factors, in Indonesia, preterm birth (Titaley et al., 2011) shorter birth interval (Perin & Walker, 2015), low birth weight (Issaka et al., 2016; Titaley et al., 2011) increase risk of under-five mortality. Also Abir et al. (2015) in Bangladesh, Shifa et al. (2018) in Ethiopia and Welaga et al. (2013) in northern Ghana found multiple birth to be associated with increased risk of under-five mortality. Low birth weight, short birth intervals and multiple birth increased risk of neonatal death Ghana (Kayode et al., 2014).

A study by Chin, Montana, and Basagaña (2011) in Nepal in 2011 found that birth order greater than one year was associated with reduced infant mortality. In Ghana, Nakamura et al. (2011) found higher risk of death among children with shorter birth intervals. The same was reported by Ogbo et al. (2019) in Tanzania. Children under one year were found to have increased risk of deaths compared to older children. While being male was associated with reduced mortality, as documented by Chin et al. (2011) in Nepal and Kazembe et al. (2012) in Senegal, the same was associated with increased mortality in Bangladesh, Nigeria and Rwanda (Abir et al., 2015; Ezeh et al., 2015;

Kazembe et al., 2012) and among children in 27 African countries (Issaka et al., 2016). Death of a sibling was positively correlated with neonatal, post neonatal, infant, child and under-five mortality in Bangladesh (Abir et al., 2015) and in Nepal (Ghimire et al., 2019).

Children born through caesarean section also have higher hazards of death among children under-five years in Nigeria between 2003 and 2013 according to Ezeh et al. (2015) in 27 African countries according to Issaka et al. (2016) and in Mali, Niger, Chad, Zimbabwe and DR Congo according to Yaya, Bishwajit, Okonofua, and Uthman (2018). Higher odds of congenital malformations deaths were found among neonates, male children, children of mothers 35years and younger in Malaysia (Zakaria et al., 2017). The common conditions were heart effects (6.7%), neural tube defects (5.8%) and hyrops fetalis (3.3%).

2.9.2 Maternal Factors

Several maternal factors affect child health. Prominent among them are maternal age, education and nutrition. Lower maternal age was associated with reduced under-five mortality compared to higher ages in Bangladesh (Abir et al., 2015), Nepal (Chin et al., 2011), in 27 African countries (Issaka et al., 2016) and Ghana (Kanmiki et al., 2014; Lambon-Quayefio & Owoo, 2014). Ezeh et al. (2015) however found increased hazard of child death with younger mothers in Nigeria and (Ogbo et al., 2019) in Tanzania. Higher maternal education have also been found to be negatively correlated with infant mortality in Nepal (Chin et al., 2011; Nattey, Masanja, & Klipstein-Grobusch, 2013) and child mortality in Bangladesh (Abir et al., 2015), Nepal (Chin et al., 2011), Ghana (Kanmiki et al., 2014), in Ethiopia (Dedefo et al., 2016) and in Malawi and Uganda

(Andriano & Monden, 2019) and among early neonates in Indonesia (Titaley et al., 2011). However, in Ethiopia, Doherty et al. (2016) found larger mortality decline among mothers with no education.

Being an employed mother was associated with higher mortality than not being employed in Bangladesh (Abir et al., 2015) and Nepal (Ghimire et al., 2019)but associated with lower neonatal and under-five mortality in Ghana (Dwomoh et al., 2019). However, (Issaka et al., 2016) found no difference in under-five mortality with working status of mother. Marriage is also shown to be protective against child mortality in Ghana (Kanmiki et al., 2014; Weeks et al., 2006) and in 27 countries (Issaka et al., 2016). Religion also influences child survival. Weeks et al. (2006) in Ghana and Kazembe et al. (2012) in Rwanda found that Christian children had increased mortality. Additionally, being from a polygamous family was found to be associated with higher mortality of children under-five years in Ghana (Kanmiki et al., 2014). Ethnicity is also documented to be associated with mortality in Mozambique (Macassa, Ghilagaber, Bernhardt, & Burstrom, 2006). In Ghana, having a mother who was from the Ga ethnic group was associated with increased child deaths (Weeks et al., 2006).

Rutherford et al. (2009) found that caregivers who had additional children to care for had reduced mortality of their children in the Gambia. Having more knowledge of child sicknesses and thus timely care seeking were the reasons for this relationship. In Bangladesh, having three or more children under-five years delivered at home was associated with lower neonatal and under-five mortality than having one to two children under-five years (Abir et al., 2015). In Rwanda, living with father or mother also reduced the risk of child mortality (Kazembe et al., 2012).

2.9.3 Household Factors

Household factors impact greatly on child survival and the general well-being of children. Larger household sizes are protective against infant and under-five mortality in Ghana (Afoakwah et al., 2015; Dwomoh et al., 2019). Important among these is wealth (McKinnon et al., 2014). Low socio-economic status manifests in poor living conditions, poor nutrition, high incidence of diseases and risk factors and less access to care (Lu, Black, & Richter, 2016; UNICEF, 2013). These put poor children at a greater risk of death. In Ghana, (Kayode et al., 2014) found living in a community of high poverty level reduced neonatal survival. Nattey et al. (2013) reported in Tanzania and (Issaka et al., 2016) in 27 African countries, lower hazards of death among the richest compared to the poorest. Also in Rwanda, odds of death was higher among children one to four years in poor households compared to rich households (Amoroso et al., 2018). In least developed countries, decrease in gross domestic product (GDP) resulted in increased U5M while an increase in GDP did not significantly affect mortality during periods of economic recessions. However, from the MDGs report, mortality rate among the poorest is declining at the faster rate (United Nations, 2015). In Ethiopia, Doherty et al. (2016) found larger decline in mortality in rural areas and do difference in mortality between rural and urban residence.

In Ghana, clusters of mortality were found among those in lower socio-economic status in the north-eastern part of the country (Adjuik et al., 2010) and in remote areas (Nettey, Zandoh, Sulemana, Adda, & Owusu-Agyei, 2010). Living in a poor neighbour was also associated with higher neonatal mortality also in Ghana (Kayode et al., 2014). However, Zere et al. (2012) found no differences in infant and under-five deaths among the poor and the rich in Ghana. Doherty et al. (2016) also observed larger mortality decline among the poorest compared to the richest in Ethiopia. The previous Northern, Upper West and Upper East regions of Ghana are the poorest regions with the Northern region home to the largest proportion of poor people (Cooke & Hague, 2016). However, between 2006 and 2013, Upper East region witnessed a huge drop in poverty from 72.9% to 44.4% compared to a decline of 55.7% to 50.4% in the Northern region according to Cooke and Hague (2016). This makes the Northern region the region with the lowest decline in poverty since 1990 (Cooke & Hague, 2016). Upper West region with the highest level of inequality followed by the Northern region and Greater Accra had the lowest in inequality. Again Upper West also had the highest increase in inequality while the greater Accra had the lowest level of poverty and the lowest increase in inequality.

Poverty, access to and quality of care are generally worse in rural areas than in urban areas. This partly explains the higher mortality rates in rural areas. However, from the literature, association of rural/urban residence with under-five mortality has inconsistent results. Residing in a rural area was positively associated with mortality in Ghana (Weeks et al., 2006), in Rwanda (Kazembe et al., 2012) and in Ethiopia (Dedefo et al., 2016). Jankowska et al. (2013) found difference in under-five mortality of up to 50 per 1,000 live births in an urban area in Accra, Ghana, but Yaya et al. (2018) found no difference in the risk of death among rural and urban dwellers while Kimani-Murage et al. (2014) documented that rural urban residence no longer impact mortality in Kenya. According to Kimani-Murage et al. (2014) there was a more rapid decline in mortality in rural areas than urban areas in Kenya attributed to higher mortality in urban slums.

The bridging of the mortality gap between rural and urban residents could also be due to the increase in interventions addressing access to care in rural areas while peculiar challenges of those in urban areas have not been addressed (Jankowska et al., 2013). Improving financial access the care can bridge this equity gap. Perinatal mortality is lower in the northern region of Ghana under NHIS compared to the cash and carry period (Ibrahim, Maya, Donkor, Agyepong, & Adanu, 2016). Higher mortality in urban settings could be due to challenges with care in urban areas especially among the urban poor due to urbanization. Exodus of rural dwellers to urban areas leads to increase in the number of urban poor who live under very deplorable conditions (Kazembe et al., 2012). These migrants might have greater challenges with accessing care due to the higher cost of living in urban areas than in the poor rural areas.

Additionally, air quality affects the incidence of infections and mortality. Cleaner fuels, especially for household cooking are being recommended for improving child survival. Pérez-Moreno, Blanco-Arana, and Bárcena-Martín (2016) documented the correlation between air pollution and poor child health. Use of liquefied petroleum gas (LPG) reduces odds of under-five mortality in Ghana (Arku et al., 2016). Gouveia et al. (2018) also found increased risk of infant mortality by air pollution in Latin America.

2.10 Healthcare Seeking Behaviour

Health care seeking behaviour (HSB) describes steps and actions taken in response to an illness and the timeliness of such actions. According to the World Health

Organization (WHO), timely and appropriate treatments prevent disease conditions from being severe and increasing the chances of death due to such conditions. Health care seeking behaviour thus influences the outcome of ill health, and is affected by individual level factors comprising both social and biological determinants of health. Social determinants are the social and economic conditions in which one lives and works. While health services must be accessible to enable individuals patronise them, poor health seeking behaviour could result in low utilization of accessible services (Rutherford et al., 2009).

The rollback malaria initiative recommends treatment of malaria within 24 hours of onset of illness to obtain the best treatment outcome (World Health Organization, 2005). Delayed care seeking has been attributed to caregivers usually waiting and hoping that symptoms will resolve, according to evidence from the Republic of Yemen (Webair & Bin-Gouth, 2013). In Ghana, sequential care seeking pattern with the use of traditional medicine is common (Bazzano, Kirkwood, Tawiah-Agyemang, Owusu-Agyei, & Adongo, 2008). In Ethiopia, several try home remedies and traditional medicine practitioners before care seeking from appropriate sources (Mitiku & Assefa, 2017). A study in Tanzania in 2004 and 2005 found that only 22.5% of children received prompt and appropriate antimalarial treatment and only 62.5% of all caretakers brought their sick children to a health facility as first action and about 45.0% of them within two days of onset of illness (Hetzel et al., 2008). In Ghana, 11% and 33% of children under-five years received treatment for malaria within 24 hours and 48 hours respectively in 2006 (Ahorlu, Koram, Ahorlu, De Savigny, & Weiss, 2006).

In a study in Burkina Faso, 55% of care givers of children with diarrhoea sought care outside the home and 78% from the public sector, 80% received some form of treatment, 24% received oral rehydration salts (ORS), 14% received antibiotics and none received zinc (Wilson et al., 2012). In another study in Tanzania, public health facilities (54.8%) and private pharmacies (23.4%) were the preferred places of first point of care for child illnesses, and utilization differed in rural and urban populations (Kahabuka, Kvale, & Hinderaker, 2013). Ferrer et al. (2016) found that care givers in Ghana preferred to use health centres and private clinics if these were their nearest health facilities. Urban and more educated women preferred higher level hospitals and private facilities (Kahabuka et al., 2013). Among new-borns with serious sickness in Ghana, care was sought outside the home for 61% of them and 39% of care sought was from a doctor or hospital (Bazzano et al., 2008). Also in Ghana, Abbey, Chinbuah, Gyapong, Bartholomew, and van den Borne (2016) found treatment of pneumonia to be mostly done using home remedies while Ameh et al. (2015) found accessibility and availability of services as reasons for the use of services of community health officers.

While some caregivers delay in care seeking and others seek care from inappropriate places, others do not seek care at all for several reasons. In the Republic of Yemen, caregivers who did not seek care have reasons such as illness not severe or not meant for medical treatment as reported by Webair and Bin-Gouth (2013). Perceived illness severity also increases odds of care seeking in Ethiopia (Gelaw, Biks, & Alene, 2014). Children with more than one symptom of disease were more likely to be taken for treatment. Also, children with symptoms such as paleness and severe sweating were found to receive more timely and appropriate treatment in Ghana (Ahorlu et al., 2006). Bedford and Sharkey (2014) identified lack of knowledge of disease presentation as barrier to care seeking while Abbey et al. (2016) and Hill, Kendall, Arthur, Kirkwood, and Adjei (2003) found low knowledge of caregivers of signs and symptoms of pneumonia in Ghana. In Ethiopia, having no history of child death delayed care seeking (Getahun, Deribe, & Deribew, 2010). In Ghana, Ganle documented poor attitude of health staff, poor quality of care and financial factors negatively influencing skilled care in Ghana (Ganle, Parker, Fitzpatrick, & Otupiri, 2014). With these gaps in knowledge of child illnesses, caregivers in SSA needed healthcare knowledge, ability to make decision and resources to access care at health facilities (Pierce, Gibby, & Forste, 2016).

In a multi-country study, maternal education, rural/urban residence and wealth were associated with prompt treatment (Shah, Emina, Eckert, & Ye, 2015). While Feikin et al. (2009) in Kenya, Malqvist, Singh, and Kc (2017) in Nepal, (Adinan, Damian, & Msuya, 2015) in Tanzania and (Ayalneh et al., 2017) in Ethiopia found that higher maternal education favour care seeking, Page et al. (2011) in Niger found no effect of caregiver's level of education on care seeking. Paternal education increased care seeking for diarrhoea and fever in Ethiopia (Ayalneh et al., 2017).

2.11 Factors Influencing Health Seeking Behaviour

On socio-economic status, higher socio-economic status increased care seeking according to Feikin et al. (2009) in Kenya and Malqvist et al. (2017) in Nepal. In Uganda, Rutebemberwa, Kallander, Tomson, Peterson, and Pariyo (2009) found that children from the poorest homes were more likely to be delayed for treatment. Health insurance membership which offers financial access to healthcare especially for the poor increased the desire to seek care and care seeking in Ghana (Blanchet, Fink, &

Osei-Akoto, 2012; Bosomprah, Ragno, Gros, & Banskota, 2015; Krumkamp et al., 2013). In Kenya, 40% of caregivers of children with malaria who use drugs bought from shops for treatment and 42% who attended formal health facilities cited lack of money as hindrance to treatment (Chuma, Okungu, & Molyneux, 2010). Seasonality of illness and income, cost of transportation and unofficial payment were the sources of financial challenges. While rural residents bear the higher weight of diseases and usually have limited access to care, caretakers residing in rural areas access care promptly in Tanzania according to Adinan et al. (2015) and Gelaw et al. (2014) in Ethiopia. However, Romay-Barja et al. (2015) found more delay among rural dwellers compared with urban dwellers in Equatorial Guinea.

On social support and household decision taking, caregiver found social network could enable or hinder care seeking in Sierra Leone (K. Scott, McMahon, Yumkella, Diaz, & George, 2014). Mother-in-laws and husbands were hindrances to the use of community health workers for treatment in Ethiopia (Shaw et al., 2016). Rutherford et al. (2009) found increased prompt care seeking among caregivers with actual or perceived social support in the Gambia. Also, in Tanzania, children living in households headed by a female were more likely to be treated early compared to those headed by males (Adinan et al., 2017). Also, monogamous marriage delayed care seeking for malaria in Ethiopia (Getahun et al., 2010). On the effect of household size on treatment seeking, Page et al. (2011) found increased treatment with increasing number of children under-five years in household in Niger. Religion and culture also affect the use of maternal, neonatal and child health (MNCH) interventions. Use of MNCH interventions was higher among Christians than among Muslims and traditional believers in Ghana (Gyimah, Takyi, & Addai, 2006).

2.12 Influence of Health System Access Factors on Health Seeking Behaviour

Access to health care has been described as a complex concept with interrelated dimensions and therefore lacks a universally accepted definition. According to Peters et al. (2008), access to healthcare is timely use of care according to need and comprises physical accessibility, availability, affordability and acceptability of healthcare services. Evans, Hsu, and Boerma (2013) also defines the scope of access to include physical accessibility, financial affordability and acceptability. These dimensions manifest in different ways and influence the utilization of and satisfaction of healthcare services (Penchansky & Thomas, 1981).

Access to healthcare is a pillar of quality healthcare (Peters et al., 2008) and according to Evans et al. (2013), universal health coverage which is a target of the sustainable development goals (SDGs) is not achievable without access to care (Boerma, 2018; Countdown to 2030 Collaboration, 2018). Thus universal health care is at the centre of the SDGs and therefore all the barriers to care seeking for treatment need to be addressed if the full benefits of treatment services are to be derived (Boerma, 2018). Lack of and an inadequate qualified health workforce and lack of treatment logistics are accessibility barriers to care seeking (Silweya, 2014; Yawson et al., 2017) and child mortality reduction (D'Acremont & Bosman, 2013). Operating hours of facilities and general organization of services were also found to affect the availability of staff and thus access to care as reported by Chuma et al. (2010). Non-availability of health personnel for treatment of MPD might have contributed to high mortality in the Kassena-Nankana district of Ghana according to (Adjuik et al., 2010). Shaw et al. (2016) also found that non-availability of staff at health post affected utilization of Integrated Community Case Management (ICCM) services in Ethiopia. According to Kahabuka, Kvale, Moland, and Hinderaker (2011) clients who did not use their nearest health facility in Tanzania gave reasons for such behaviours as unavailability of diagnostic facilities (42.2%) and drugs (15.5%), closed health facility (10.2%), poor services (9.7%) and lack of skilled health workers (3.4%). Alba et al. (2010) found no difference in promptness of treatment between patients who had been treated in health facilities and those treated in drug shops in Tanzania. Evidence on the effect of presence of traditional medicine practitioners or traditional treatment option on care seeking is not conclusive. Muro et al. (2017) found no effect of traditional care on treatment seeking but D'Acremont et al. (2014) found reduced care seeking with availability of traditional medicine.

Distance to place of healthcare is one of the major aspects of physical accessibility to formal healthcare services affecting many people and thus shaping healthcare utilization (Ferdous et al., 2013; Muro et al., 2017; Tefera et al., 2014) and child mortality especially in developing countries (Kadobera, Sartorius, Masanja, Mathew, & Waiswa, 2012). In Kenya, about 60% of clients attended health facilities within a 5 km range and found distance to nearest public health facility and nearest drug retail shop to be 2 km and 1 km respectively (Noor, Zurovac, Hay, Ochola, & Snow, 2003; Smith et al., 2011). Also in Ghana, about 70% of the population lived more than 8km from the nearest healthcare provider in 1990 (Nyonator, Awoonor-Williams, Phillips, Jones, & Miller, 2005). Also in Kenya, O’Meara et al. (2009) found an average walking distance to nearest facility of 73 minutes with 68% and 13% of the children residing more than 1 hour and 2 hours walk respectively from the nearest health facility. In a similar study by Ferdous et al. (2013), caregivers travelled more than 4miles to access care for treatment of diarrhoea.

Distance to health care has been shown to reduce care seeking (Krumkamp et al., 2013) and increased chances of hospitalization (O’Meara et al., 2009) and death (Målqvist, Sohel, Do, Eriksson, & Persson, 2010). Bedford and Sharkey (2014) further identified, travel time, distance/location of health facilities, long waiting time at facility as barriers to care seeking. In rural Ethiopia, distance showed marked influence on under-five mortality (Okwaraji et al., 2012) and according to Turuse, Gelaye, and Beyen (2014) in Kenya, children living ≥5 kilometres from the nearest health facility were about twice as likely to be delayed for care than those at the shorter distances. Still in Kenya, frequency of clinic visits reduced by 34% for every 1 km extra distance from a clinic, and 95% of caregivers travelled less than 5 km for health care services (Feikin et al., 2009). In another study in Kenya, travel distance to health facilities influenced the incidence of hospitalization which increased twice for those living two hours from health facilities compared with those within 2 minutes of the vicinity of health facilities (O'Meara et al., 2009). In Tanzania, Kadobera et al. (2012) reported an increase risk of mortality of 17% for children living more than 5 km from the nearest health facility compared with those living closer. Caregivers who went to shops or community medicine distributors and those who saw distance to place of care as short were less likely to delay treatment of their children in Uganda (Rutebemberwa et al., 2009).

Adjuik et al. (2010) suggested that poor health system could account for the higher mortality in some villages in the Upper East region of Ghana while Atuoye et al. (2015) lack of transportation to undermine the impact of Community-based Health Planning Services (CHPS) in a CHPS zone in the Upper West region of Ghana. However, in Sierra Leone, D'Acremont et al. (2014) found no effect of distance on care seeking for diarrhoea and fever. Evidence on the effect of presence of traditional medicine practitioners or traditional treatment option on care seeking is not conclusive. Muro et al. (2017) found no effect of traditional care on treatment seeking but D'Acremont et al. (2014) found reduced care seeking with availability of traditional medicine.

Cost of healthcare, an aspect of financial affordability, has been acknowledged as a major concern of health care seekers and thus the call for universal health coverage (UHC) of health services (United Nations, 2015). The reason for UHC is to prevent financial hardships from accessing healthcare. Most healthcare cost in Africa is out-of-pocket payment (Chuma et al., 2010). However, in Ghana, the National Health Insurance Scheme (NHIS) was implemented to ensure the affordability of healthcare services. This has shown to increase care seeking for maternal and child health services (Bosomprah et al., 2015). It also showed reduced odds of death and hazard rates of infant and under-five mortality in 2008 (Dwomoh et al., 2019). About 95% of diseases are covered under the scheme (Lawson & Essuman, 2016). In Zambia, however, cost per out-patient visit for under-five pneumonia and cost per bed day were US$215 and US$48 respectively while that per outpatient visit attributed to under-five diarrhoea and the cost per bed day US$26 and US$78 respectively (Chola & Robberstad, 2009). Still in Zambia, cost per case correctly diagnosed and treated was US$4.22 for home management of malaria and US$6.12 for facility level (Chanda et al., 2011).

Ferrer et al. (2017) found that in 2014 cost of treatment in terms of time spent going to a provider, time at provider, money spent on transportation and direct and indirect household cost of treatment were higher for those seeking care from CHPS facilities than from ICCM community based agents. These were $0.04, $0.11 and $0.04 for malaria, diarrhoea and pneumonia with Community Based Agent (CBA) and $0.91, $0.72 and $1.24 malaria, diarrhoea and pneumonia at CHPS compounds. Travel distance to provider accounted for a greater portion of the difference which was $0 for CBAs and $0.18 for CHPS (Ferrer et al., 2017). Costs of drugs were $0.00, $0.08 and

$0.00 for malaria, diarrhoea and pneumonia for CBAs but $0.12, $0.03 and $0.54 for CHPS.

To finance healthcare, caregivers devise means including borrowing money from others or getting treatment on credit (Chuma et al., 2010). Bedford and Sharkey (2014) identified lack of knowledge of cost of hospital treatment and loss of productive time as barriers to care seeking. Caregivers in Ethiopia were also not aware of the availability of free treatment services for children under-five years offered by health extension workers (Shaw et al., 2016). Some caregivers did not also trust that treatment was free (Shaw et al., 2016).

On the acceptability of health care services, Bedford and Sharkey (2014) identified poor communication between staff and clients and negative previous experience at facility preventing care seeking and according to Manu et al. (2014), poor attitude of healthcare staff limited impact of intervention on child mortality in Ghana. Lack of fit between clients and any of these dimensions lead to dissatisfaction with healthcare services. In Kenya, according to Chuma et al. (2010), 55%, 36.9% and 8.0% respectively of clients who sought care at formal health facilities were dissatisfied, satisfied and indifferent to the quality of care provided. Quality of drugs received, lack of drugs, low confidence in staff and lack of diagnostic services were the reasons for dissatisfaction while availability and effectiveness of drugs, confidence in staff and short waiting times caused satisfaction.

Ferrer et al. (2016) also found availability and affordability of drugs, long distances, operating hours and staff not giving information the reasons for dissatisfaction with treatment services in Ghana. in Ghana, Ameh et al. (2015) also, found effectiveness of medicine the reason for accessing care from hospitals, health centres and drug stores. Safety of multiple immunization caused fear among caregivers of children (Yawson et al., 2017). Acceptability and patient-worker relations were perceived as better with community health workers compared to formal health workers, but rated as equal in performance with clinical services between the two groups.

2.13 Efforts at Increasing Access to Care at the Primary Health Care Level

Access to health care has been acknowledged as a major concern of health care seekers. Global efforts at improving access to primary healthcare dates back to the 1978 Alma-Ata Declaration of Health for All (Peters et al., 2008; Taylor, 2003; World Health Organization, 1978). The declaration emphasised as unacceptable the disparities in the health status of the people. It describes primary healthcare as:

> "Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It forms an integral part both of the country's health system, of which it is the central function and main focus, and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and community with the national health system bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process" (TO, 2003).

This access to care is a function of the primary healthcare process in addition to continuity, coordination and comprehensiveness of care (Kringos, Boerma, Hutchinson, van der Zee, & Groenewegen, 2010). Many governments, including the Government of Ghana, have over the years instituted measures to improve access to primary healthcare for their populace by promoting healthcare service at community levels. Some of such interventions are the ICCM programme, Home Based Care (HBC and CHPS programme in Ghana (Ministry of Health, 2016; Nyonator et al., 2005; World Health Organization, 2005). Integrated community case management programme, which is an initiative aimed at addressing barriers to access to care was added to the HBC programme to address the challenge of access to care and facilitate achievement of MDG 4 (Young et al., 2012). By this, Community Based Agents were trained on the major causes of U5M and given drugs to treat these conditions within their communities. The ICCM programme became integrated into CHPS in 2016 due to low patronage of the ICCM services. CHPS was introduced in 1999 (Awoonor-Williams et al., 2010) to further address the challenge of accessibility to care. It was instituted in line with the objectives of the Alma Ata Declaration of 1978 (Ghana Health Service, 2005) and it is the country's primary tool to achieving universal health coverage (Ministry of Health, 2016).

The CHPS programme in Ghana reduced travel distance to the nearest health facility from 14 km in 1998 to less than 9 km in 2004. Also, 44% of households lived less than 10km from a facility before the implementation of CHPS and this increased to more than 63% of households living within 10 km of a health facility after the programme was implemented (Awoonor-Williams et al., 2010). National Health Insurance addresses issues of financial accessibility to treatment of MDP (Nyonator et al., 2005) while HBC enabled mothers treat minor child ailments at home (WHO, 2002).

2.14 Methods in Impact Evaluation

Impact evaluation is a method of assessing the effectiveness of interventions, programmes or policies (Gertler, Martinez, Premand, Rawlings, & Vermeersch, 2011). It aims to determine whether an intervention, programme or policy is achieving what it is intended to achieve or a particular outcome can be attributed to an intervention, programme or policy. To make causal attributions, there have to be a causal link between the intervention, policy or programme and the outcome. Impact evaluation is therefore an approach to making causal inference of programmes, policies or interventions. In 1965 Sir Austin Bradford Hill proposed a criteria for establishing a causal relationship between exposure and outcome (Rothman & Greenland, 2005). The following are the tenets of the Bradford Hill criteria of establishing causality:

- There is a strong association between the exposure and outcome (strength).
- That the exposure precedes the outcome (temporality).
- Results of the association are consistent over time in different population under different circumstances (consistency).
- That the mechanism of the association does not contradict that known about the natural history of the relationship (coherence).
- Presence of a unidirectional dose curve (biological gradient).
- That the exposure-outcome relationship can be demonstrated in and experiment (experiment).
- Similar observation of exposure-outcome relationship is observed in different fields (analogy).
- That the exposure results in a single outcome (specificity) and
- Biological plausibility of the hypothesis (plausibility) (Rothman & Greenland, 2005).

2.14.1 Quasi-Experimental Methods

Randomized experiments are the gold standards for the assessment of the causal effect of interventions. The strengths of the randomized trial is its ability to control for both known and unknown confounders and thus measured and unmeasured confounders. However, randomization in intervention studies is sometimes not possible for ethical or programmatic reasons. To address the challenge of lack of random assignment to treatment in observational studies, several methods have been developed for the estimation of treatment effects in non-randomized studies. These methods are referred to as quasi-experimental methods. Quasi-experimental methods include matching, instrumental variables, regression discontinuity, regression adjustment and mathematical modeling (Stuart, 2010). Coarsened exact matching (CEM) is a type of matching method, logistic regression is a type of regression adjustment while Lives Saved Tool (LiST) modeling is a modeling method.

Matching methods used in the estimation of causal effect approximate randomized experiments in that they ensure that there is balance in pretreatment variables (variables that could influence treatment assignment) between those who received the intervention and those who do not receive the intervention (Stuart, 2010). The untreated group therefore becomes the counterfactual. The validity of quasi-experimental studies depend on the plausibility of the assumption of strong ignorability and positivity probability (Stuart, 2010). By positivity probability, it means that both treated and untreated had none-zero chances of receiving the opposite treatment. This means that the treatment group could by chance (at random) be untreated and the untreated group, could by chance also be treated. This is similar to what happens in a randomized experiment where before randomization, all study participant have a none-zero chance of receiving either of the treatment.

Strong ignorability/confoundedness states that after conditioning (matching) on covariates and achieving balance between the treated and untreated groups, the effect of unobserved potential confounders is negligible and therefore, the treatment effect estimated are unconfounded (Stuart, 2010). Confounding occurs when the effect of one variable on another is distorted by a third variable.

Coarsened exact matching involves pruning observations that have no close matches on pre-treatment covariates in both the treated and control groups. The control group becomes a counterfactual (what would have happened without the interventions) (Gertler et al. 2011). This makes the data less model dependent (results do not change with changes in the statistical model used in the estimation of the impact after matching) and possesses less bias data (King and Zeng, 2006; Ho et al., 2007; Iacus, King and Porro, 2011, 2012). Matching methods include propensity score matching, mahalonobis metric matching and coarsened exact matching.

2.15 Methods Used in Literature Review

Key words were identified from the topic. Key words/phrases used were: “impact” “mortality”, “lives saved”, “child”, “under-five years” interventions and determinants. These were linked using Boolean operators “and” and “or” in databases for the literature search. Databases included Pubmed, Scopus and EBSCOhost. Google scholar was also used. The advanced search options of the databases was used. Titles were read and if articles were judged to be useful, PDFs were downloaded and citations exported into endnote desktop. When key articles were retrieved from the databases, titles were searched in google scholar and “related articles” and “cited by articles” also retrieved. The cycle was repeated if other key articles were retrieved. Articles included were those for which study participants were children under-five years and article was written in English. Studies should have estimated mortality or additional lives saved or factors associated with under-five mortality.

2.16 Summary of Gaps in Literature

Information on the impact of maternal, neonatal and child health interventions on neonatal and child mortality in Ghana and in each of its ten regions is limited. Decline in mortality in each of the ten regions of Ghana vary, and the reasons for the differences in mortality and mortality decline are not well understood which this study sought to provide. The two most recent Ghana Demographic and Health Survey were used to assess the impact of the various interventions using coarsened exact matching and lives saved tool. Impact evaluation was done at the individual and population levels. Different methods were used to strengthen the validity of the results because of the assumptions of the various methods used for the evaluation. Determinants of mortality were also assessed to see the effects of the various interventions on mortality, while controlling for demographic factors to support the results from the impact evaluation.

CHAPTER THREE

METHODS

3.1 Study Design

The study design was a quasi-experimental study design. The base line for the evaluation was 2008 and the end line was 2014. Impact was estimated at the individual level as well as at the population level. The list of interventions evaluated at each level and the reasons for the evaluation at those level (s) are presented in Table 1. For the individual level analysis, the interventions groups were children who received each of eight (8) interventions. These eight interventions are expected to be implemented before, during or shortly after birth and are therefore, likely to have preceded death for those children who received them (temporal association between exposure and outcome) (Rothman & Greenland, 2005).

The control groups (counterfactual) were a statistically created control groups using coarsened exact matching (CEM). The counterfactual for the population level analysis was the impact of interventions if intervention coverage levels did not change between baseline (2008) and end line (2014). This mean the impact would be zero (0).

Table 1: Interventions and Risk Factors and Level at Which Impact was Evaluated

<table>
<tr><th>Number</th><th>Intervention/risk factor</th><th>Level at which impact was estimated</th><th>Reason</th></tr>
<tr><td>1</td><td>Tetanus toxoid vaccination (protection from neonatal tetanus)</td><td rowspan="6">Both individual and population level</td><td>Not applicable</td></tr>
<tr><td>2</td><td>Intermittent Preventive Treatment of malaria in pregnancy, (IPTp)(at least 2 doses)</td><td>Not applicable</td></tr>
<tr><td>3</td><td>Early breastfeeding(EIB)(within 1hour)</td><td>Not applicable</td></tr>
<tr><td>4</td><td>Iron intake (for at least 90 days)</td><td>Not applicable</td></tr>
<tr><td>5</td><td>Skilled delivery (SD)</td><td>Not applicable</td></tr>
<tr><td>6</td><td>Clean postnatal care (CPC) with 2 days</td><td>Not applicable</td></tr>
<tr><td>7</td><td>Antenatal care (4plus visits)</td><td>Individual level only</td><td>Not in the LiST</td></tr>
<tr><td>8</td><td>Hygienic disposal of stool</td><td>Individual level only</td><td>Impact not estimated in LiST because of lack of documented effectiveness as stated in the LiST</td></tr>
<tr><td>9</td><td>Health facility delivery</td><td>Population level only</td><td>Highly correlated with skilled delivery</td></tr>
<tr><td>10</td><td>Household ITN/IRS</td><td rowspan="4">Population level only</td><td rowspan="4">Temporality was not clear</td></tr>
<tr><td>11</td><td>Improved sanitation</td></tr>
<tr><td>12</td><td>Improved water source</td></tr>
<tr><td>13</td><td>Water connection in the home</td></tr>
<tr><td>14</td><td>Complementary feeding</td><td>Population level only</td><td>Not applicable to neonates</td></tr>
<tr><td>15</td><td>Pentavalent vaccine</td><td rowspan="13">Population level only</td><td rowspan="13">Children who died did not have information on these interventions</td></tr>
<tr><td>16</td><td>Measles vaccine</td></tr>
<tr><td>17</td><td>Pneumococcal vaccine</td></tr>
<tr><td>18</td><td>Rota virus vaccine</td></tr>
<tr><td>19</td><td>Haemophilus type b vaccine</td></tr>
<tr><td>20</td><td>ORS for diarrhea</td></tr>
<tr><td>21</td><td>Antibiotics for dysentery</td></tr>
<tr><td>22</td><td>Zinc for diarrhea</td></tr>
<tr><td>23</td><td>Oral antibiotics for pneumonia</td></tr>
<tr><td>24</td><td>ACTs for malaria</td></tr>
<tr><td>25</td><td>Exclusive breastfeeding</td></tr>
<tr><td>26</td><td>Vitamin A (2 doses)</td></tr>
<tr><td>27</td><td>Stunting and wasting(risk factors)</td></tr>
</table>

Impact assessment was done for 26 interventions and two risk factors (stunting and wasting) in this study (Table 1). Six (6) interventions were evaluated at both the individual and population levels, while two (2) were evaluated at the individual level only. Lastly, 24 interventions had their impacts assessed at the population level.

3.2 Source of Data

Secondary data from Ghana Demographic and Health Surveys (GDHS) were used for this study. Secondary data are data that were collected primarily for one purpose and have been used for another purpose (Johnston, 2017). Based on my research objective (to assess the impact of maternal, neonatal, child health and nutrition interventions on under-five mortality) and from the literature review, appropriate secondary data were available to answer my research objective. Rutstein (2000) has indicated that GDHSs have several interventions known to impact mortality and were therefore, suitable data sources for the analysis. Also, according to Johnston (2017), with the existence of large data bases, secondary data analysis for research work has become common.

The data sets were assessed, and were found to contain information of most of the child health interventions and mortality in Ghana. Response rates were over 90% for both the 2008 and 2014 surveys (Ghana Statistical Service (GSS) et al., 2015). The data were therefore, suitable for the research work. Further checks were done to assess their quality including checking for missing and unexpected values in the data sets. Missing data were found in both the 2008 and 2014 data sets and the missing data were addressed using multiple imputation. Unexpected values (pregnant women receiving twenty-four doses of sulphadoxine-pyremethamine during one pregnancy) were detected for the intervention, intermittent preventive treatment of malaria in pregnancy. Officials of the DHS User Forum and the National Malaria Control Programme of

Ghana were contacted on the unexpected data values of IPTp and the issue is being investigated.

The Ghana Demographic and Health Surveys data are collected by the Ghana Statistical Service with technical support from the DHS program (Demographic Health Survey). Data collection methods and variables are similar across demographic surveys and in countries in which demographic and health surveys are conducted. This allows for comparability of study results across GDHS and similar resourced countries. The data sets, tools and manuals on how the data should be analyzed were also accessible (Croft et al., 2018).

Data sets of the 2008 (children born from 2003 and 2008) and 2014 (children born from 2009 to 2014) GDHSs were used for the analysis. The years 2008 and 2014 were chosen because GDHS data sets were available for these years and they are the GDHS data sets closest to the transition from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs). Information from the study would therefore, provide an understanding of which interventions contributed the most to mortality reduction towards the end of the MDGs, and those that should be focused on during the SDGs period in order to achieve rapid mortality reduction among children under-five years old.

3.3 Design of the Ghana Demographic and Health Surveys (GDHSs)

Ghana Demographic and Health Surveys are complex household surveys. They have been conducted since 1988 and the 2008 and 2014 are the fifth and sixth GDHS respectively. Ghana Demographic and Health Surveys data were collected using a cross-sectional descriptive study design. Maternal, neonatal, child health and nutrition interventions on which data were collected during these surveys were implemented at different time periods. New interventions including rota virus and pneumococcal vaccine were introduced between 2008 and 2014.

Individuals selected for the survey were selected using a multistage cluster sampling technique. The country was stratified by region, and rural urban settings of each region. The data is therefore, nationally and regionally representative. The primary sampling units were census enumeration areas (EAs), which were considered as the clusters. These were selected using probability proportional to size sampling methodology. Household with these clusters were selected randomly, and eligible individuals in these households interviewed. Anthropometry and biochemical measurements were taken from some study participant including measurement of height, weight, malaria and haemoglobin test.

Questionnaire were administered to different members in a household including caregivers of children under-five years old, aged 15-49 years old. Thus, the GDHS data sets are different corresponding to the different groups. There are data sets for households labelled as household recode (HR) file, all household members known as persons recode (PR) file, women 15 to 49 years old labelled as individual recode (IR) file and children known as children's recode (KR) file, among others. The HR, KR and PR files were used for this analysis. The children's recode file was the main data set and it contained information on children under-five years old at the start of the data collection whose mothers where interviewed. Mothers were aged 15-49 years. The 2014 data set had 5,884 observations and 1,159 variables, while the 2008 GDHS had 2882 observations and 1010 variables. The variables of interest in this present study included socio-demographic variables, child health status, water and sanitation, vaccination, morbidity, treatment and mortality information. Table 2 contains information on key GDHS variables that were used in this analysis and the data sets containing such information.

Table 2: Data Sets Used and the Variables in them that were Used

Data set	Variables used
KR	Age group of child, age group of mother, National Health Insurance Scheme Membership (NHIS) status of mother, sex, area of residence, region, ethnicity, caregivers level of education, household socio-economic status, neonatal tetanus protection, clean postnatal care, improved water, improved sanitation, hygienic disposal of stool, water connection in the home, time to improved water source, early initiation of breastfeeding, exclusive breastfeeding, intermittent preventive treatment of malaria in pregnancy, iron intake, health facility delivery, skilled delivery, diphtheria, pertussis and tetanus (DPT) vaccine, measles vaccine, pneumococcal vaccine, rota virus vaccine, artemisinin-based combination therapy (ACTs), oral rehydration salts (ORS), zinc for the treatment of diarrhoea, care seeking for pneumonia, antibiotics for dysentery, vitamin A supplementation and complementary feeding
PR	Stunting and wasting
HR	Indoor residual spraying or ownership of at least one bed net (ITN/IRS)

The Stata version of the data sets were downloaded from the DHS Program's website (https://dhsprogram.com) after permission was granted by the authorities of the DHS program. The HR data sets were merged with the KR data sets so that household insecticide treated nets/indoor residual spraying (ITN/IRS) information from the household file could be added to the KR data set for the individual level analysis. The PR data sets were used to calculate stunting and wasting prevalence for the population level data analysis. Key variables in the KR file included socio-demographic variables (maternal age and education, child's age, sex, region and area of residence and wealth index) and intervention variables (antenatal care visits, postnatal care visit, early initiation of breastfeeding, health facility and skilled delivery and household ownership of mosquito net). Details of all variables used in the analysis are in Table 3.

3.4 Key Demographic variables in demographic health survey

Table 3: Ghana Demographic and Health Survey variables

Variable name	Operational definition of variable	Scale of measurement	Type of variable
1. Age group	Age	Ordinal	Independent
2. Membership of NHIS among children	Children under-five years and has a valid NHIS cards or not	Nominal	Independent
3. Sex	Male or female	Nominal	Independent
4. Area of residence	Rural or urban	Nominal	Independent
5. Region	Type of religion	Nominal	Independent
6. Ethnicity	Type of ethnic group	Nominal	Independent
7. Caregivers level of education	Highest level of education	Ordinal	Independent
8. Household socio-economic status	Level of household wealth	Ordinal	Independent
9. Under-five mortality rate	The probability of dying between birth and the fifth birthday	Nominal	Outcome
10. Death	Dead or alive	Nominal	Outcome
11. Interventions (neonatal tetanus protection, clean postnatal care, improved water, improved sanitation, hygienic disposal of stool, water connection in the home, time to improved water source, early initiation of breastfeeding, exclusive breastfeeding, intermittent preventive treatment of malaria in pregnancy, iron intake, health facility delivery, skilled delivery, diphtheria, pertussis and	Individual received intervention or did not receive intervention	Nominal	Independent

tetanus (DPT) vaccine, measles vaccine, pneumococcal vaccine, rota virus vaccine, artemisinin-based combination therapy (ACTs), oral rehydration salts (ORS), zinc for the treatment of diarrhoea, care seeking for pneumonia, antibiotics for dysentery, vitamin A supplementation, complementary feeding), stunting, wasting and indoor residual spraying or ownership of at least one bed net			

3.5 Study area

The study area was Ghana. There were 10 regions and 216 districts in Ghana in 2008 and 2014. The regions were, Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Northern, Upper East, and Upper West regions. Figure 4 below shows the map of the study area. At the last census in 2010, total population of Ghana was about 25 million (Ghana Statistical Service, 2013). The Ashanti, Eastern and Greater Accra regions were the most populous regions accounting for half of the population, while the Upper East region was the least populated region, constituting 2% of the population. There are several ethnic groups in Ghana including the Akans (48%), Mole-Dagbani (17%), Ewe (14%), Ga-Dangme (7%) and others (Ghana Statistical Service, 2013).

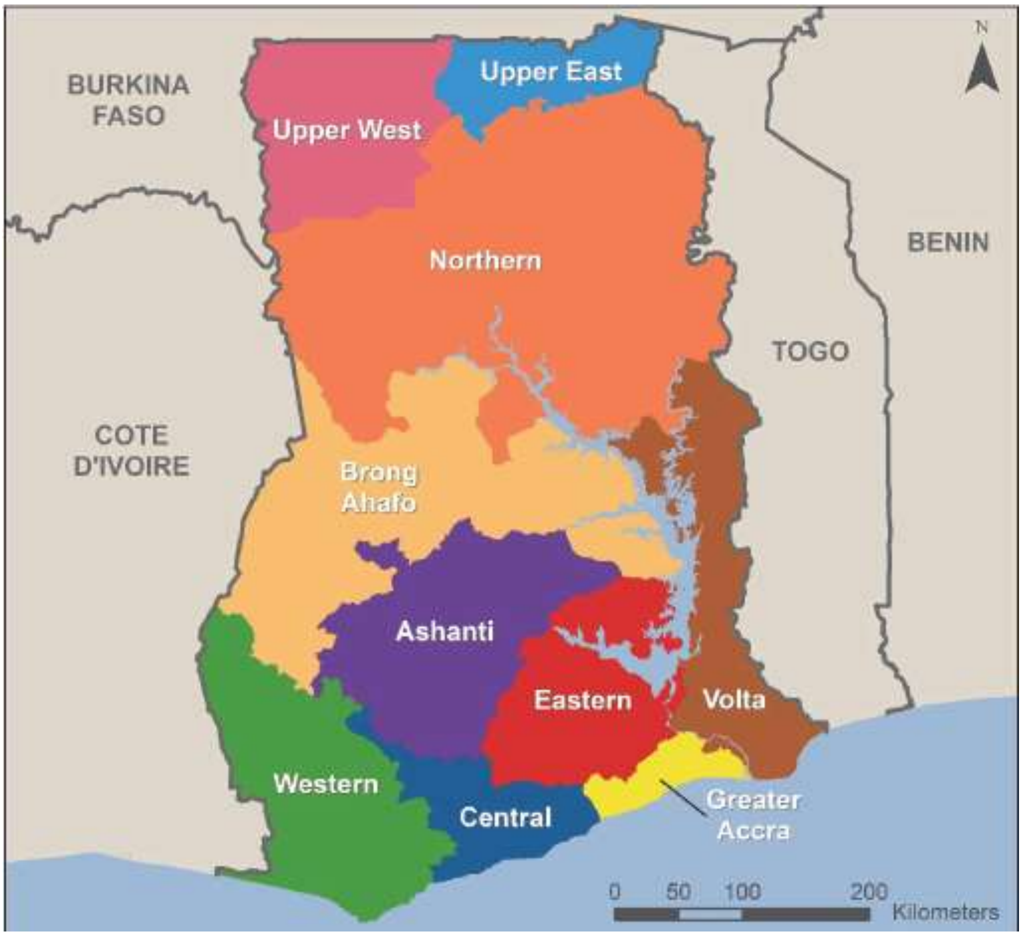


Figure 4: Map of Study Area

Source: Ghana Statistical Service, 2014 GDHS

3.6 Geography

Ghana is a country in sub-Saharan Africa (SSA) with a total land mass of 238,537 square kilometres. It shares boundaries with Togo on the east, Burkina Faso to the north and northwest, Côte d'Ivoire on the west and Gulf of Guinea to the south. Ghana has a tropical climate. The average annual temperature is about 26ºC. There are two distinct rainy seasons in the southern and middle parts of the country, from April to June and September to November. Northern Ghana has one rainfall season that begins in May and ends in September. Annual rainfall ranges from about 1,015 millimeters in the North to about 2,030 millimeters in the Southwest. Harmattan, a period of dry dusty desert wind accompanied with low humidity and visibility occurs between December and March mostly in the northern part of the country. In the southern part of the country, the Harmattan is experienced mostly in January. Harmattan is associated with increased risk of meningococcal meningitis (Codjoe & Nabie, 2014). Climate change and weather variability are projected to worsen in Ghana in future and consequently, food security and health are at risk (Asante & Amuakwa-Mensah, 2015; Codjoe & Owusu, 2011).

3.7 Economy

The economy has historically been agriculture based. However, this was replaced by the services sector by 2014 making the services sector the fastest growing sector of the economy (Ghana Statistical Service, 2014). The services sector contributed 52% of the Gross Domestic Product (GDP), followed by the industry sector (27%), and the agriculture sector (22%) in 2014. About 44.7% of the economically active population (15 years and above) is engaged in agriculture and 40.9% provide services (Ghana Statistical Service, 2014). A high proportion (80%) of the employed population of Ghana works in the informal sector, the majority being self-employed (Osei-Boateng & Ampratwum, 2011). Wages from non-farm self-employment contributes the most (48.3%) to household income followed by that from employment and agriculture (Ghana Statistical Service, 2014). Export commodities of Ghana include cocoa, gold, timber, pineapples, bananas, yams and cashew nuts.

Over the past decade, the government of Ghana has embarked on various economic and poverty reduction programmes designed to improve the living conditions of its citizenry. The Livelihood Empowerment Against Poverty (LEAP) programme was introduced in 2007 and funds disbursement started in 2008, while the School Feeding Programme started in the 2005-2006 academic year. The government introduced the school feeding programme with the aim of improving the nutritional status of its beneficiaries (Quaye, Essegbey, Frempong, & Ruivenkamp, 2010). To meet the 2025 target of a 40% reduction in child mortality means Ghana has to attain a stunting prevalence of at most 11.3% and a wasting prevalence of 5%. However, in 2008 stunting prevalence among children 6 months to four years was 28%, while wasting was 8.5%. Stunting prevalence decreased to 18.8% and wasting also decreased to 4.7% in 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

3.8 Demographic Profile

According to the Ghana Statistical Service, Ghana's population density has increased over the years from 29 persons per square kilometer (persons/km2) in 1960 to 103 persons/km2 in 2010 (Ghana Statistical Service, 2010). The proportion of the population living in urban areas has more than doubled from 23 percent in 1960 to 51 percent in 2010. The sex ratio was 95.2 males per 100 females in 2010 (Ghana Statistical Service, 2010).

High fertility rates and low contraceptive prevalence have been cited as reasons for the high under-five mortality rate in Sub-Saharan Africa (SSA) (Murray et al., 2007). In the Northern region of Ghana where under-five mortality rate is highest in the country, fertility rate is the highest, while contraceptive prevalence is the lowest in the country (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). In 2008, total fertility rate (TFR) was four (4) with the highest in the Northern (6.8) and Upper West (5) regions and the lowest in the Greater Accra (2.5), Eastern (3.6) and the Ashanti region (3.6) (Ghana Statistical Service (GSS) et al., 2009). In

2014, TFR was 4.2 nationally and was highest in the Northern (6.6) and Upper West (5.2) regions and lowest in the Greater Accra (2.8) and Western (3.6) regions (Ghana Statistical Service (GSS) et al., 2015). Modern contraceptive prevalence rate in 2008 was 13.5% and highest in the in the Greater Accra (22.2%) and Brong Ahafo region (21.6%), but lowest in the Northern (5.7%) and the Upper East regions (14.3%). In 2014, the national modern contraceptive prevalence rate increased to 22.2% and was highest in the Volta (29.5%) and Central (27.5%) and the Greater Accra (19.4%) regions but lowest in the Northern (10.8%) (Ghana Statistical Service (GSS) et al., 2009).

On general health, the of illness or injury was 14% in 2014 with individual 50 years and above (22.4%) and children 0-5 years (20.3%) reporting the highest burden (Ghana Statistical Service, 2014). The average cost of medical care was GHS 88.03 with rural residents spending more (GHS 147.77) than those in urban areas. Household members (54.5%) and NHIS (41.5%) were the sources of funding for health care (Ghana Statistical Service, 2014). Health insurance coverage was 67.6% in 2014 (Ghana Statistical Service, 2014).

3.9 Study Population

The study population was children under-five years old in the GDHS data sets born between 2003 and 2014

3.10 Analytic Tools

Ghana Demographic and Health Surveys data were collected using a descriptive cross-sectional study design but to enable the investigator answer the research questions (to assess impact of interventions and determinants of under-five mortality), the data were analyzed as cross-sectional analytic data and also as quasi-experimental data. Therefore, different analytic tools were used. The effects of the interventions were estimated at the individual level using Coarsened Exact Matching (CEM), while the Lives Saved Tool (LiST) was used for the estimation of impact at the population level (using population level data instead of individual level data). Determinants of mortality were assessed using logistic and Poisson regressions, and survival analysis done using Cox proportional hazard regression. Coarsened Exact Matching, logistic regression and the creation of survival graphs were done in Stata (StataCorp, 2013), while the LiST analysis was done in the LiST located in the Spectrum software which was downloaded from www.avenirhealth.org.

3.11 Survival Analysis

Survival analysis measures the time it takes for events to occur in a study. Since the objective of the work was to assess the effect of interventions on mortality, survival analysis was an appropriate analytic tool. In this work, it was used to estimate the effect of each intervention on the time it takes for a child to die from birth. Cox proportional hazard regression was used to create the survival graphs to describe the survival for the interventions.

3.12 Regression Analysis

Logistic regression is a type of regression for modeling binary outcomes, while Poisson regression models counts and rates. These were used to assess factors associated with mortality. Odds ratios, incidence rate ratios and 95% confidence intervals and p-values were reported.

3.13 Coarsened Exact Matching

Coarsened Exact Matching (CEM) was the matching method used to evaluate the impact of the interventions (effect of receiving interventions on mortality) (Blackwell, Iacus, King, & Porro, 2009; Firestone, 2015). Matching and therefore CEM, is a counterfactual approach to impact evaluation. A matching method was used since the data for this study is observational (cross-sectional data) and therefore, prone to confounding because of non-random treatment assignment (selection bias). Selection bias occurs in a study when the choice of whether one receives an intervention or not is not random as in randomized experiments.

In observational studies, the intended exposure is not assigned by the investigator. In this study, because the exposure was not assigned (mothers of children under-five years decided to receive the exposure or not to receive the exposure), the relationship observed between the intervention and mortality could be due to factors that influenced the individual's decision to receive the exposure and not the exposure itself. This is referred to as selection bias.

Matching addresses the issue of selection bias that can lead to confounding in observational studies by matching on baseline covariates (individual characteristics) likely to influence individuals' choice to receive the intervention or not treatment assignment. Confounding is a spurious relationship between treatment and outcome due to a third variable. Matching ensures that baseline characteristics (example maternal age and education, household wealth, area of residence, region, ethnicity and religion) of those who received the intervention and those who did not receive the interventions are balanced (equivalent) as happens with random assignment of treatment in randomized trials. Balanced in baseline (pretreatment) characteristics between those who received the intervention (treated) and those who did not receive the intervention (not treated) allows for unbiased estimation of the causal effects of interventions on the outcomes. Imbalance is measured using the Linear 1 (L1) statistic.

Matching creates a counterfactual (untreated group) similar to that produced in randomized experiment and thus, allows for the estimation of causal effects. Thus, matching methods are referred to as quasi-experimental analytic tools. Variable (covariates) matched on should be factors likely to influence an individual choice to receive the intervention or influence mortality and such factors should precede the reception of the intervention. In this study, these were region, area of residence, wealth, household size, maternal education, maternal age and birth interval. These covariates were used for matching for the different interventions.

There are different types of matching methods, and the type of matching technique used could affect the internal and external validity of the study results (Bai, 2011; McMurry, Hu, Blackstone, & Kozower, 2015). Other matching methods include propensity score and Mahalonobis matching (Becker & Ichino, 2002). Coarsened exact matching falls within the class of matching methods referred to as Monotonic Imbalance Matching methods. Monotonic imbalance means that the change in the imbalance of one variable does not affect the maximum imbalance in any other covariate.

Coarsened exact matching was chosen for this work because it easily allows for the incorporation of survey weight. In addition, CEM meets the congruence principle, does not need to restrict data to common support, estimates robust standard errors and it is faster to work with. The congruence principal posits that the data processing space should be similar to the data analysis space (Blackwell et al., 2009). Coarsened exact matching meets this principle because the analysis of the treatment effect is done on the uncoarsened (ungrouped) data after observations without matches are deleted. Therefore, the form of the data before matching and after matching is the same (no data transformation occurs).

Coarsening is the creation of categories of variables for the easy identification of matches. While exact matching is the ideal matching method, with many covariates, exact matching results in few or no matches, and consequently, a very small sample size and loss of representativeness of the data and power of the sample. In CEM, after the coarsening, exact matching is done within the strata of the groups created. Strata without observations are dropped and the analysis done with the uncoarsened data. The use of the uncoarsened data for analysis makes the CEM method meet the congruence principle. The level of coarsening can be automatic (determined by the software) or user defined (researchers choses how variables should be categorized). A user defined option was used in this analysis. This option was chosen to ensure that categories of the variables created made clinical sense and are comparable with categories in the GDHS reports.

3.13.1 Steps in Coarsened Exact Matching Analysis:

1. Observations are temporally coarsened (grouped) only for matching and not for analysis
2. Observations are put into bins, each bin with an identity
3. Exact matching is done using the identity

4. Unmatched observations are dropped
5. Analysis is done with the raw (uncoarsened data). Analysis is done using any method that could have been used without the matching. In this work, logistic and Poisson regressions were fitted (Blackwell et al., 2009; Firestone, 2015).

3.13.2 **Imbalance Checking**

Imbalance checking is done using the linear statistic (L1). Its values range from 0 to 1 (Firestone, 2015). A value of zero (0) means perfect balance, while a value of one (1) means perfect imbalance. Therefore, the closer the value to zero, the lower the imbalance. Values ranging from 0 to 0.2 are usually considered appropriate for imbalance reduction.

3.14 Lives Saved Tool

Lives saved tool (LiST) is a multi-cause deterministic mathematical population level modelling tool used for evaluation and attribution. It is able to determine the impact of multiple interventions or programmes implemented simultaneously including those affecting pregnant women and children (Fox, Martorell, Van Den Broek, & Walker, 2011; Friberg & Walker, 2014; Garnett, Cousens, Hallett, Steketee, & Walker, 2011; Victora, 2010). The lives saved tool has been used retrospectively to assess interventions that contributed to mortality reduction in some countries (Ethiopia, Niger, Tanzania and Malawi) that achieved the MDG4s (Afnan-Holmes et al., 2015). It was first developed in 2003 for evaluating the impact of community level interventions and it is updated continuously with new information (Tam & Pearson, 2017; Victora, 2010).

Information in LiST include: incidence and prevalence of diseases, prevalence of risk factors (preterm, low birth weight, stunting and wasting), causes of death (eight in neonatal period and nine in post-neonatal period) and coverage levels of interventions. Neonatal causes are diarrhoea, sepsis, pneumonia, asphyxia, prematurity, tetanus, congenital anomalies and other. Those of the post-neonatal period are diarrhoea, pneumonia, meningitis, measles, malaria, pertussis, AIDS, injury and other.

There were over 70 interventions in LiST at the global level as at 2011 (Fox et al., 2011; Winfrey, McKinnon, & Stover, 2011). Data for the modelling in LiST comes from different sources. These include intervention coverage data from household surveys such as the Demographic and Health Surveys (DHS), Multiple Indicator Cluster Survey (MICS) and Malaria Indicator Survey (MIS) of countries and population data from the United Nation Population Division. Causes of deaths data come from the Child Health Epidemiology Reference Group (CHERG), while mortality data comes from the UN Inter-agency Group for Child Mortality Estimation (IGME). LiST has been validated and used in studies in countries across the world including Ghana (Amouzou et al., 2012; Bryce et al., 2010; Friberg et al., 2010; Hazel et al., 2010; Kanyuka et al., 2016; Keita et al., 2017; Larsen, Friberg, & Eisele, 2011).

Auxiliary tools in the spectrum software that are used together with LiST for the estimation of impact of interventions on under-five mortality and thus, were used in this study include demographic engine (DemPro), AIDS Impact Module (AIM) and family planning module (FPLAN) (Winfrey et al., 2011). The spectrum software with these tools was downloaded from www.avenirhealth.org. Figure 5 shows a schematic diagram of the interactions between LiST and other tools.

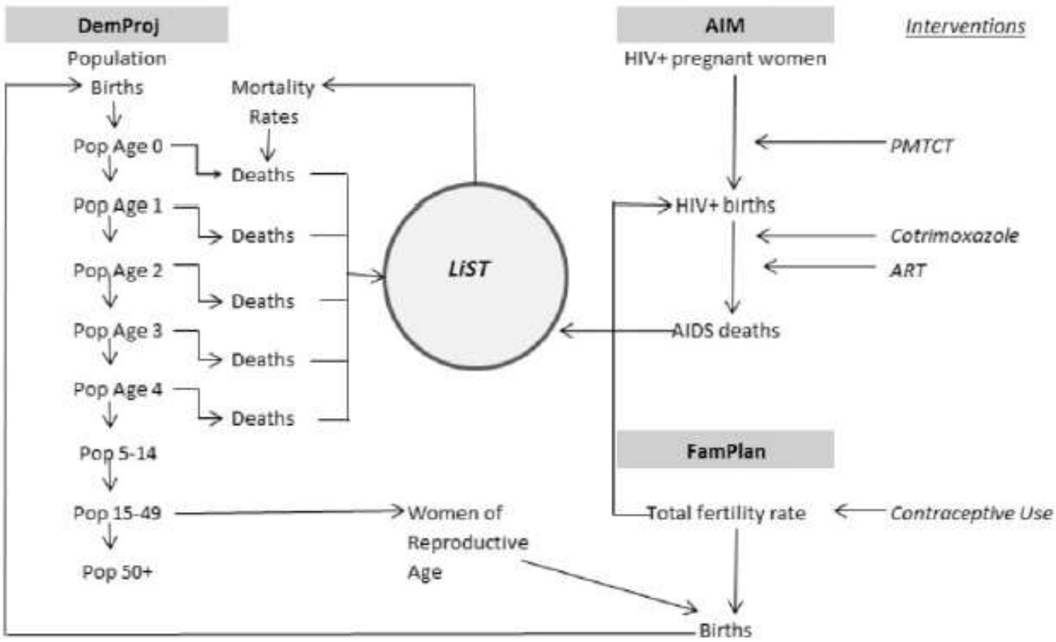


Figure 5: LiST Interaction with AIM, DemProj and AIM Modules

Source:(Stover, McKinnon, & Winfrey, 2010)

3.14.1 Lives Saved Tool Assumptions and Limitations

While there are several interventions that can influence under-five mortality, those included in the LiST have effectiveness information at the global level. Thus not all interventions are in the LiST (Druetz, 2018). The assumption in LiST is that interventions are effective (an acknowledged limitation) and therefore, that increase in coverage of interventions will reduce mortality, while decrease in coverage will result in additional deaths than previously (Winfrey et al., 2011). Socio-demographic factors are not included in LiST, but it is assumed that their effect on mortality is still accounted for in the model through their effect on coverage of interventions. Socio-demographic factors like wealth, maternal education and age and areas of residence influence access to health care interventions and therefore, coverage levels of these interventions (Victora, 2010). The assumption that all skilled delivery use appropriate and immediate assessment and stimulation or have access to neonatal resuscitation, if needed is a challenge. Also, the consideration of burial of stool as an hygienic way of stool disposal can be challenged because burial on or close to a playground of children, and especially when the hole is shallow, could lead to contamination of the soil (Bain & Luyendijk, 2015).

The collection of demographic, AIM and Famplan information and coverage of interventions of a particular population constitute a projection in LiST. Once a projections is created, the projection can be used in other tools for further analysis. The missed opportunity is also in the spectrum software and uses projections created in LiST to estimate impact of interventions if coverage levels are individually scaled up to 90%, one at a time.

3.14.2 Lives Saved Tool Modelling Procedure

Lives saved tool makes projection of the population under study using the DemPro (demographic projection) and calculates births and deaths that should occur in that population. The effect of family planning services to the number of births is applied using information from the FamPlan module, while the effect of AIDS on mortality is also applied using information from the AIM (AIDS impact module). With the number of deaths estimated, coverage levels of interventions targeted at reducing mortality are applied to the population. Based on the effectiveness of the intervention(s) delivered in that population, the projected deaths in the population is expected to change relative to the changes in the coverage levels of the interventions. Interventions are expected to reduce the number of deaths that should occur in the population. Figure 6 below is a schematic diagram on the LiST methodology.

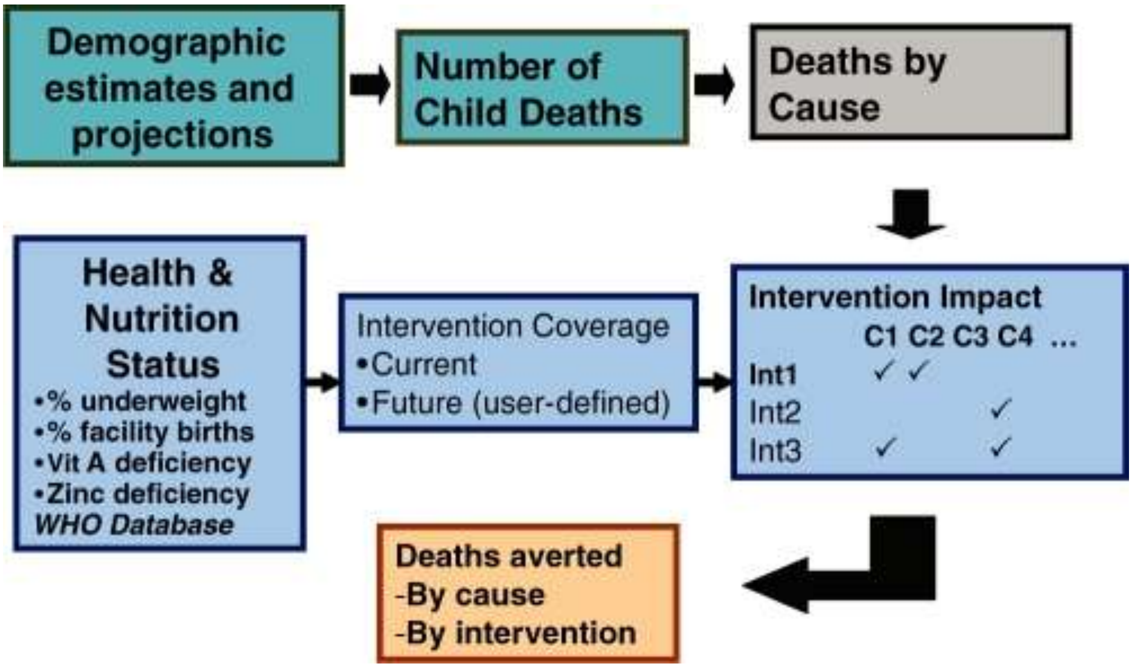


Figure 6: Lives Saved Tool methodology

Source (Boschi-Pinto, Young, & Black, 2010)

Preventive interventions operate at reducing deaths first before curative interventions. Also, peri-conceptual and pregnancy related intervention operate first before interventions meant to reduce mortality later in life consecutively (Winfrey et al., 2011). Lives saved tool also models the impact of interventions on intermediate outcomes such as wasting and stunting on mortality.

3.15 Missed Opportunity Tool

The missed opportunity tool uses projections created in LiST to calculate the impact of interventions assuming current coverage levels of interventions are scaled up to 90% individually (Tam & Pearson, 2017). It helps to determine which interventions would make the greatest impact if current levels are scaled up to 90% in the following year (2015). It was used to determine the number of lives that would be saved if each of the 24 interventions was individually scaled up to 90%. It therefore, determines the interventions that will make the most impact if coverage levels are increased. Although 90% is the default coverage level in the missed opportunity tool, it is also the target coverage level of vaccines for the Ghana Health Service (Ghana Health Service, 2015a).

3.16 Information Used in Lives Saved Tool Analysis

The information that the software, LiST, uses in the estimation of impact of interventions on under-five mortality include prevalence or incidence of diseases, total fertility rate, contraceptive prevalence, neonatal, infant and under-five mortality rates, interventions coverages, intervention effectiveness and affected fractions. Coverages of interventions used for the LiST analysis are included in Figure 7.

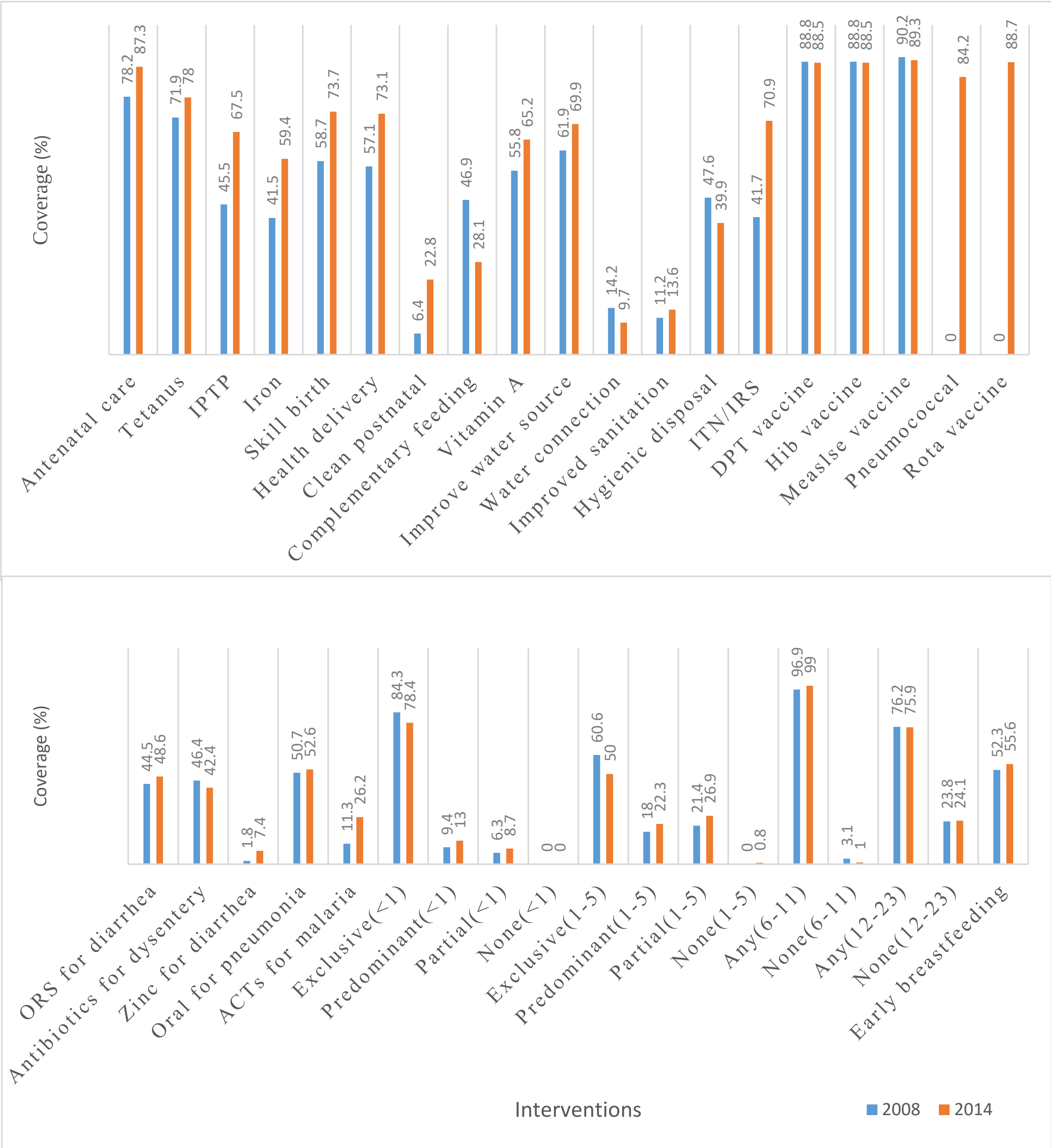


Figure 7: Coverage of Interventions in 2008 and 2014 at the National Level

Source: Ghana Demographic and Health Survey reports (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009)

3.17 Intervention or Indicator Definitions

Definitions of inputs used for this analysis were based on the definitions used in the LiST www.avenirhealth.org. This was to enable comparability of results from the different data analysis tools. Although these definitions used in LiST are universally accepted, there are issues with the validity and accuracy of some of these definitions. It is well known that not all fever cases are malaria and therefore, the use of fever as a proxy for malaria is problematic. However, considering the low level of malaria testing, there could not have been a better alternative. Information used for the LiST analysis is presented in Table 4.

Table 4: Definition of Information Used for Live Saved Tool Analysis

Inputs entered	Definition	Source of default data in LiST	Source used in analysis
Demproj			
Population		2010 census	GSS
Total fertility rate (TFR)	Average number of children that a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as children per woman	UN population division	GDHS.
FAMPLAN			
Contraceptive prevalence rate (CPR)	Percent of women of reproductive age who are in union and who use contraception	GDHS	GDHS
AIM			
HIV incidence or prevalence	Frequency of existing disease in a defined population at a specific time	GDHS	GDHS
LiST			
Tetanus toxoid (TT) vaccination: Percent of neonates who are protected at birth (PAB) from tetanus infection.	Percent of women who received two doses of tetanus toxoid during this pregnancy or ever: Received at least 2 doses, the last within 3 years; received at least three doses, the last within 5 years; received at least 4 doses, the last within 10 years; or received at least five doses during lifetime. Also known as TT2+.	WHO/ UNICEF	GDHS
Intermittent preventive treatment of malaria during pregnancy (IPTp)	Percent of pregnant women receiving 2+ doses of Sulphadoxine pyrimethamine /Fansidar during pregnancy	GDHS	GDHS
Iron	Percent of pregnant women taking an iron supplement daily, for at least 90 days.	GDHS	GDHS

Skilled birth attendance(SBA)	Percent of children born with a skilled attendant present, including doctors, nurses, or midwives, in a facility or at home. An SBA in the home is defined as a skilled birth attendant who delivers the infant at home without benefit of referral to a facility in case of emergency. A SBA in a facility is defined as a medically skilled attendant who has the ability and facilities needed to monitor labor progress with a partograph and detect complications. Episiotomy is available, if needed.	GDHS	GDHS
Health facility delivery	Percent of children born in a health facility	GDHS	GDHS
Labor and delivery management	Percent of women receiving labor and delivery management from a skilled birth attendant. The default assumption is that 100% of SBAs in the home and 100% of institutional deliveries have access to the appropriate facilities for the given level of care.	GDHS	GDHS
Clean postnatal care practices	Percent of neonates where the mother washes her hands frequently, the child lives in a clean environment, and no harmful practices. Coverage data for this indicator are not typically available. As a proxy, it is assumed that all neonates receiving a preventive postnatal visit within 48 hours of delivery will subsequently receive adequate clean postnatal care in the home. Coverage data for this proxy indicator are drawn from DHS, MICS, and other nationally representative household surveys	GDHS	GDHS
Complementary feeding - education only	Percent of mothers intensively counseled on the importance of continued breastfeeding beyond six months and appropriate complementary feeding practices. As a proxy, the percent of 6-23 month old children receiving minimum dietary diversity (4+ food groups) is used.	GDHS	GDHS
Complementary feeding - supplementary feeding and education	Percent of mothers intensively counseled on the importance of continued breastfeeding beyond six months and appropriate complementary feeding practices, and given appropriate dietary supplementation. As a proxy, the percent of 6-23 month old children receiving minimum dietary diversity (4+ food groups) is used)	GDHS	GDHS
Vitamin A supplementation	Percent of children 6-59 months of age receiving two doses of Vitamin A during the last 12 months.	UNICEF	GDHS
Improved water source within 30 minutes	Percent of households with access to an improved water source within a 30 minute walk	WHO/UNICEF/JMP	GDHS
Water connection in the home	Percent of households with a household connection, including water piped into the home or yard.	WHO/UNICEF/JMP	GDHS
Improved sanitation	Percent of households using an improved sanitation facility (defined as flush or pour flush to piped sewer system, septic tank, or pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab; or composting toilet).	WHO/UNICEF/JMP	GDHS
Hygienic disposal of children's stools	Percent of children’s stools that are disposed of safely and contained. Stools are considered to be contained if: 1) the child always uses a toilet/latrine, 2) the feces are thrown in the toilet/latrine, or 3) the feces are buried in the yard.	DHS	GDHS
ITN/IRS - Households protected from malaria	Percent of households owning at least one insecticide treated bed net (ITN) and/or protected by indoor residual spraying (IRS).in last 12 months	DHS	GDHS
DPT vaccine	Percent of children who survive the first year of life who have received 3 doses of DPT vaccine	WHO/UNICEF	GDHS
Hib vaccine	Percent of children who survive the first year of life who have received 3 doses of Hib vaccine	WHO/UNICEF	GDHS

Measles vaccine	Percent of children who survive the first year of life who have received 1 dose of measles vaccine.	WHO/UNICEF	GDHS
Pneumoccocal 3doses	Percent of children who survive the first year of life who have received 3 doses of pneumococcal vaccine	WHO/UNICEF	GDHS
Rota virus 3doses	Percent of children who survive the first year of life who have received 2 or 3 doses of Rota virus vaccine (according to manufacturer's schedule)	WHO/UNICEF	GDHS
ORS for treatment of diarrhea	Percent of children 0-59 months with suspected diarrhea treated with oral rehydration solution (ORS), including sachets or pre-mixed solutions. This indicator does not include homemade sugar-salt solution or recommended home fluids due to lack of adequate data.	GDHS	GDHS
Antibiotics for treatment of dysentery	Percent of children 0-59 months with bloody diarrhea who receive appropriate antibiotic treatment (including ciprofloxacin, ceftriaxone, and pivmecillinam).	GDHS	GDHS
Zinc for treatment of diarrhea	Percent of children 0-59 months with suspected diarrhea treated with 20mg of zinc daily	GDHS	GDHS
Oral antibiotics for pneumonia	Percent of children with suspected pneumonia (symptoms of acute respiratory infection) and care sought from a health facility or provider.	GDHS	GDHS
Artemisinin-based Combination Therapy (ACTs)	Percent of children treated within 48 hours of the onset of fever in malaria-endemic areas with an artemisinin-containing compound.	GDHS	GDHS
Exclusive breastfeeding	Percent of children receiving only breastmilk for food (plus medication, vaccines, and vitamins). Applicable to children less than 1month and 1-5months	GDHS	GDHS
Predominant breastfeeding	Percent of children receiving only breastmilk plus water and/or other non-milk liquids such as juices (plus medication, vaccines, and vitamins). Applicable to children less than 1month and 1-5months	GDHS	GDHS
Partial breastfeeding	Percent of children receiving breastmilk plus complementary foods and/or milk-based liquids (plus medication, vaccines, and vitamins). Applicable to children less than 1month and 1-5months	GDHS	GDHS
None breastfeeding	Percent of children not receiving any breastmilk. Applicable to children less than 1months and 1-5months	GDHS	GDHS
Any breastfeeding (6-11)	Percent of children still receiving any breastmilk. Applicable to children less than 6-11months and 12-23months	GDHS	GDHS
Early initiation of breastfeeding	Percent of children who begin breastfeeding within 1 hour of birth. Applicable to children less than 0-59months	GDHS	GDHS
Stunting	Distribution of the percent of children falling into one of four Z-score categories for height for age: <-3Z (severe stunting), -3 to -2Z (moderate stunting), -2 to -1Z (mild stunting), and >-1Z (not stunted). Stunting reflects chronic undernutrition. Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups	GDHS	GDHS
Waiting	Distribution of the percent of children falling into one of four Z-score categories for weight for height: <-3Z (severe wasting), -3 to -2Z (moderate wasting), -2 to -1Z (mild wasting), and >-1Z (not wasted). Wasting reflects acute undernutrition. Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups. Disaggregated data are not available for 0-1 and 1-5 months. As a proxy, the 0-6 month values are applied to both age groups	GDHS	GDHS

Source: Lived Saved Tool

3.18 Data Management/Processing

The manuals for the GDHS data analysis were downloaded from the DHS Program's website (https://dhsprogram.com). These manuals were studied to understand the contents of the data sets and variables in the data sets that were appropriate for the analysis. The KR and HR data sets for the years 2008 and 2014 were merged. The KR data sets were the master data sets. The 2008 KR data set had 2,992 observations and 1,394 variables, while the 2014 KR data set had 5,884 observations and 1,394 variables. The merged data set therefore, had a total 8,876 observations and 1,394 variables. Cluster (v001) and household numbers (v002) were the unique identifiers used for the merger. After the merger of the KR and HR files for 2008 and 2014, the merged 2008 and 2014 data sets were then appended (combined) to obtain the final data set which contained both the 2008 and 2014 data sets. This combined data set was used for the individual level analysis. The data sets were appended to ensure a large sample size for more precise estimates.

The individual level analysis using the merged data was restricted to only last births and usual residence of households. The restrictions were done because questions on some interventions (antenatal care visits, postnatal care, iron and folic acid intake) were asked for only the last births. Restricting analysis to only last births will also limit the effect of recall bias. Children who were not usual residents were not eligible for some questions (improved sanitation and time to improved water source) and therefore had missing data for those variables. Also, since household factors, including household size, wealth and location impact child morbidity and mortality, inclusion of household visitors could bias the results since their visiting households could be different from their original households.

As part of the data management, some variables were recoded and new variables created. Variables with categories of 'don't know' coded as 8, 9, 99, 999 were recoded to missing. For interventions, 'don't know' was considered as not having received the intervention. This convention is what is used in the GDHS data analysis (Croft et al., 2018). For child's weight, birth interval, maternal age, delivery type, number of cowives, don't know was recoded as missing. Variables with missing values were child's weight, birth interval, maternal age, delivery type, number of cowives and NHIS in the data set. New variables created were: skilled delivery, health facility delivery, clean postnatal care, neonatal tetanus protection, weight of child, early initiation of breastfeeding, insecticide treated net or indoor residual spraying, child's age and time to event. Correctness of variables created was checked by sorting and browsing the old and new variables together and also summarizing the variables. As a further quality check, results were matched with those in the 2008 and 2014 GDHS reports for which similar results are presented.

3.18.1 Multiple Imputation

Forty-eight (48) percent of observations had at least one missing value for the covariates to be adjusted for and therefore, multiple imputation was done before the regression analysis was done. Imputation was done to preserve the sample size and representativeness of the data. Variables with missing data were birth interval (16 observations), number of cowives (832 observations), mode of delivery of child (2 observations), child's weight (19 observations), employment status of mother (13 observations), and NHIS status (2,458 observations). National Health Insurance Scheme status had the most missing data since it was measured for only a subsample of the study population. Twenty (20) imputations were done using chain imputation and logistic regression. Imputation data format was marginal long and seed set was 200. Variables used in the multiple imputation were all variables without missing data that were used in the analysis. The design feature, weighting, was factored into the multiple imputation model. All the missing values were successfully imputed. The imputed data set was used for the regression and CEM analysis.

3.19 Data Analysis Procedures

3.20 Descriptive Statistic

The data were declared as survey data before all the analyses were done. Declaring data as survey data takes into account the design features of the GDHS study design and sampling methodologies (stratification, clustering, primary sampling unit and probability weight). The strata was region, while the primary sampling units (PSUs) was enumeration areas (EAs). Bi-variable analysis (Chi-square test) was done using the svy tabulate command in Stata. Socio-demographic factors and coverage levels of interventions were calculated for 2008 and 2014, and for the combined data set.

3.21 Survival Analysis

For survival analysis, the data was declared as survival time data. Survival time was age in weeks and failure was dead. Data analysis was done among all children under-five years old. Cox proportional regression modeling was used to create the survival graphs and check if the graphs were different for those who received each intervention and those who did not receive each intervention. Survival graphs were created for each intervention and probability values (p-values reported). Probability values less than 0.05 showed that survival curves of those who received each intervention differed from those who did not receive each intervention.

3.22 Impact Evaluation

Impact evaluation was done using individual level data and also at the population level because of data limitation at the individual level as presented in Table 1. Individual level analysis was done only for interventions (8 interventions). These eight interventions were the interventions for which data was collected for all children (those alive and those dead at the time of the survey) and they met the condition of temporal relationship between exposure and outcome. Thus, interventions that were received before or shortly after birth were included. Temporal relationship means that the exposure preceded (occurred before) the outcome. In this study, temporality meant that the exposure occurred or likely occurred before the death of children who received them. These 8 interventions were: neonatal tetanus protection, clean postnatal care, hygienic disposal of stool, early initiation of breastfeeding, IPTp, iron intake, skilled delivery and antenatal care visit.

Impact evaluation at the population level was done for 24 interventions. These interventions were neonatal tetanus protection, clean postnatal care, early initiation of breastfeeding. Others were IPTp, iron intake, skilled delivery, place of delivery, exclusive breastfeeding, DPT vaccine, measles vaccine, pneumococcal vaccine, rota virus vaccine, haemophilus type b vaccine. Lastly, ACTs, ORS for the treatment of diarrhoea, zinc for the treatment of diarrhoea, care seeking for pneumonia, antibiotics for dysentery, vitamin A supplementation, complementary feeding, household ITN/IRS, improved sanitation, improved water source and water connection in the home were also included.

3.23 Impact Evaluation at the Individual Level

3.23.1 Pre-Processing of Data

All interventions were categorized as binary in accordance with the requirement for the CEM analysis. Preprocessing of data before analysis aims to address selection bias that could lead to confounding. It seeks to achieve balance in pretreatment covariates (factors that influenced receiving the intervention) as occurs with randomization in experimental designs. With balance in pretreatment covariates, treatment effects can therefore be attributed to the intervention. For the matching process, the outcome variable used for the prediction of treatment was each of these interventions: skilled delivery, water connection in the home, improved sanitation, ITN/IRS, time to improved water source, protection from neonatal tetanus, folic acid, early breastfeeding, place of delivery and clean postnatal care. Variables used in matching were potential confounders strongly associated with under-five mortality from the literature review and were also associated with the intervention from chi-square test done (Table 5). Potential confounders are variables that are related to the exposure and the outcome in a study but are not intermediates in the causal pathway of the exposure and outcome (Brookhart et al., 2006). These included, survey year, region, wealth, maternal age, maternal education, birth interval and antenatal visits.

Table 5: Pre and Post-Matching Information on Intervention among Children 0-59 Months

	Number of observations and level of bias before matching			Variables used in matching	Number of observations and level of bias after matching			Variables adjusted for in the regression after matching
Intervention	Unexposed	Exposed	Imbalance	Variables matched on	Unexposed	Exposed	Imbalance	
Tetanus toxoid vaccine (protection from neonatal tetanus)	19,023	45,135	L=0.37	Survey year, region, wealth, ethnicity, antenatal care, and employment status of mother	18,509	43,789	L1=4.10x10^{-15}	Child's sex, birth weight, birth interval, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Skilled delivery	25,769	38,389	L=0.52	Survey year, region, place of residence, maternal age, maternal education, religion, and birth order	24,586	33,822	L1=3.05x10^{-15}	Child's sex, birth weight, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Early initiation of breastfeeding (within 1hour)	30,031	34,127	L=0.17	Survey year, region, maternal age, delivery type, skilled delivery, and antennal visits	29,937	34,127	L=5.62x10^{-14}	Child's sex, birth weight, birth interval, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Intermittent preventive treatment of malaria in	29,920	34,238	L=0.45	Survey year, region, wealth, maternal	26,825	33,019	L=2.45x10^{-14}	Child's sex, birth weight, birth interval, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron

pregnancy(>=2 doses)				education, religion, and antennal visits				intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Hygienic disposal of stool	39,026	25,132	L=0.35	Survey year, region, wealth, maternal age, maternal education, and cowives	38,211	24,949	$L=2.12x10^{-14}$	Child's sex, birth weight, birth interval, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Iron intake (>=90days)	35,931	28,227	L=0.36	Survey year, region, religion, ethnicity, birth interval, and antennal visits	32,695	27,966	$L=2.67x10^{-14}$	Child's sex, birth weight, birth order, multiple birth, child's age, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, delivery type, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Antenatal visits (>=4 visits)	15,113	49,045	L=0.49	Survey year, region, wealth, maternal education, religion, and ethnicity	14,381	35,451	$L=2.62x10^{-15}$	Child's sex, birth weight, birth interval, birth order, multiple birth, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, antenatal care, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.
Clean postnatal care (within 2 days)	53,845	10,313	L=0.38	Survey year, region, maternal education, religion, NHIS, and antennal visits	49,115	10,298	$L=1.57x10^{-14}$	Child's sex, birth weight, birth interval, birth order, maternal age, maternal education, marital status, contraceptives use, region, place of residence, ITN/IRS, skilled delivery, clean postnatal care, antenatal care visits, IPTp, iron intake, survey year, improved water source, hygienic disposal of stool, religion, ethnicity, cowives, household size, mothers employment status, early initiation of breastfeeding, number of children under-five in household and NHIS status.

3.23.2 Analysis

After matching, analysis was done to determine the treatment effect of each intervention using logistic and Poisson regressions. The outcome was death and exposure was each of the eight interventions for the bi-variable analysis. For the multivariable analysis, each of the eight interventions was an exposure. All the other interventions and socio-demographic factors were adjusted for in the model. These variables adjusted for included: sex, child's weight, birth interval and order, multiple birth, maternal age and education, marital status, contraception use, household size, region, area of residence, wealth, improved sanitation, ITN/IRS, skilled delivery, survey year, time to improved water source, religion, ethnicity, number of cowives, caregiver employment status and survey year. The design features (stratification, clustering and weighting and selection of primary sampling units) of the GDHS were factored in to the analysis. Treatment effects were reported as odds ratios with 95% confidence interval and p-values.

3.24 Impact Evaluation at the Population Level

The population level analysis was done using the LiST. Lives saved tool contains default national data of Ghana for 2008 and 2014. The data was loaded into the tool and the base line for the impact evaluation set at 2008 and the end line 2014. Default mortality rates and coverage levels of interventions were replaced with those calculated. Scale-up between 2008 and 2014 was done and lives saved and mortality reduction reported. The configuration was changed to allow for estimates based on direct entry of stunting and wasting, and lives saved and mortality reduction also reported.

For analysis to assess the impact of interventions at scale-up of coverage levels to 100% coverage of interventions, the projection created was used. Coverages levels of all the

24 interventions were scaled up to 100% in 2014, and neonatal and under-five mortality rates reported. For the missed opportunity, another projection was created with 2014 as the baseline. Default mortality and intervention coverages were replaced with those calculated and the projection saved. This projection was loaded into the missed opportunity tool and lives saved reported.

3.25 Assessment of Determinants of Under-Five Mortality (Regression Analysis)

The pooled multiple imputed data of the 2008 and 2014 GDHS was used for this analysis. The data was restricted to last births and usual household members. Pearson correlation was done to check for multicollinearity before analysis. Skilled delivery and place of delivery were correlated and skilled delivery was maintained. Wealth and areas of residence were moderately correlated (correlation co-efficient was 0.6), but because both wealth and area of residence were of interest, both were maintained. Logistic and Poisson regression models were fitted (Charmarbagwala et al., 2004). The data was declared as survey data taking into account design effects (clustering, stratification and weighting). Testpam was used for the post estimation. Statistical significance was pegged at an alpha of 5%. Odds ratios and 95% confidence intervals and p-values were reported.

3.26 Sensitivity Analysis at the Individual Level Data Analysis

Complete case analysis

1. When logistic regression was done with the complete cases including NHIS, the total number of observation was 3,195, and early initiation of breastfeeding, child’s age and NHIS were associated with U5M from the adjusted analysis.

Since the sample size reduced significantly when missing values were dropped, some variables (type of delivery, multiple birth, number of children under-five years old in the household, religion, and time to improved water source) had cells with values less than five (5) observations and were not adjusted for in the analysis.

2. When the analysis was repeated but without NHIS, the sample size was 5,225 and there was covariate balance for all covariates. Birth interval, multiple birth, child's age, cowives, early initiation of breastfeeding and number of children less than five years in the household were associated with U5M from the adjusted analysis.
3. For the CEM analysis with completed cases, sample size after matching for the regression analysis ranged from 2,300 to over 3,000 observations. Only early initiation of breastfeeding had causal effect on U5M reduction from both the crude and adjusted analysis.

3.27 Quality Control

Quality control in data analysis was done to ensure accuracy of the analysis procedures and results. On data issues, officials of the DHS program and the National Malaria Control Programme of Ghana were contacted on the unusual data values of IPTp. In the 2008 data set, some women received as many as 24 doses of sulpadoxine pyremethamine (SP) during one pregnancy.

For the analysis, some descriptive results were matched with results in the GDHS reports (example antenatal care visit, breastfeeding and iron intake) to cross-check the results. Double data entry and analysis were done for the LiST and the missed opportunity analysis and the manuals on these analysis followed strictly.

3.28 Limitations of the Study

These was no vaccination, morbidity and treatment information for children who died, and thus, impact assessment could not be done for these interventions at the individual level. The LiST assumes constant effectiveness of intervention which might not always hold. Although there was no information available for impact evaluation at the individual level, analysis was done at the population level. Also, with under-five mortality, the greatest burden occurs among neonates and most of the interventions assessed at the individual level apply to children within the neonatal period. The effect of the limitation of assumption of effectiveness at the population level on the study findings was assessed from the results from the individual level analysis.

3.29 Strengths of the Study

On the strengths of the study, nationally representative data were used. The sample size was large and response rates were high (over 90%) for both surveys. The use of different analytic tools (Lives Saved Tool, Coarsened Exact Matching, logistic regression and survival analysis) and the consistency of some results across methods adds to the validity of the study results and thus, the strength of the study.

3.30 Ethics Issues

Ethical clearance was obtained from the Ghana Health Service Ethics Committee. The identification number was GHS-ERC: 010/02/18.

3.31 Privacy / Confidentiality

The data that were used for the analysis did not contain personal identifiers and therefore, there could not have been a breach of confidentiality.

3.32 Funding Information

The study was partly funded by International Fellowships Programme Alumni Awards, USA.

3.33 Declaration of Conflict of Interest

None declared.

CHAPTER FOUR

RESULTS

The results section presents descriptive statistics of study participants, impact of interventions and determinants of mortality with the aim of identifying interventions that contributed significantly to mortality reduction between 2003 and 2014 among children under-five years in Ghana. Descriptive statistics and determinants of mortality included child factors, maternal and household factors and interventions. Impact assessment was done for the various exposures (maternal and child health interventions) that were implemented between 2003 and 2014 in Ghana.

4.1 Socio-Demographic Characteristic of Children Under-Five Years Who Died

There were 2,045 children under-five years and 40 (1.9%) deaths in 2008. In 2014, total number of children was 4,053 and deaths were 53 constituting 1.2%. In the combined data set, there were 6,098 children under-five years and 93 (1.5%) died.

On child characteristics, at baseline (year 2008), as shown in Table 6, children less than one month constituted 2.2% of children under-five years. Among children who died, 46.0 % were less than one month old. Low birth weight was 12.0% for all children and 13.2% among children who died. At end line (2014), children less than one month old formed 1.6% of all children, and 47.8% of those who died. Low birth weight prevalence was 11.5% among all children, and 15.1% among those who died. In the combined data set, among children who died, 47 (47.0%) were less than one month old.

Table 6: Child Factors of Children Under-Five Years Who Died

Year	Baseline (2008)		End line (2014)		Combined	
Characteristics	Total n (%)	Died n (%)	Total n (%)	Died n (%)	Total n (%)	Died n (%)
Age(months)						
<1	46 (2.2)	20 (46.0)***	68 (1.6)	27 (47.8)***	114 (1.8)	47 (47.0)***
1 to 5	294 (14.1)	6 (13.5)	545 (12.7)	7 (12.2)	839 (13.2)	13 (12.8)
6 to 11	319 (15.2)	7 (16.9)	577 (14.8)	8 (15.2)	896 (14.9)	15 (16.0)
12 to 59	1386 (68.6)	7 (23.6)	2863 (71.0)	11 (24.7)	4,249 (70.1)	18 (24.2)
Female	1002 (48.4)	13 (30.3)	1935 (47.3)	30 (56.9)	2,937 (47.7)	43 (45.0)
Birth size (<2.5kg)	266 (12.0)	6 (13.2)	505 (11.5)	10 (15.1)	771 (11.7)	16 (14.3)
Preceding birth interval						
<2 years	188 (9.5)	6 (18.5)	342 (9.2)	7 (13.9)	530 (9.30)	13 (16.0)
Birth order						
<3	1191 (59.7)	14 (42.6)*	2318 (59.8)	23 (44.6)	3509 (59.7)	37 (43.7)*
(>=3)	854 (40.3)	26 (57.4)	1735 (40.3)	30 (55.4)	2,589 (40.3)	56 (56.3)
Gestation						
Singleton	1994 (97.5)	35 (85.7)***	3951 (97.5)	49 (93.3)***	5945 (97.5)	84 (89.9) ***
Multiple birth	51 (2.5)	5 (14.3)	102 (2.5)	4 (6.7)	153 (2.5)	9.0 (10.1)
Caesarean delivery	130 (7.1)	4 (13.9)	442 (10.5)	5 (10.5)	572 (11.1)	9.0 (12.0)
Total	2045 (100)	40 (100)	4053 (100)	53 (100)	6098 (100)	93 (100)

*p<0.05. **p<0.01, ***p<0.001

Note: sample size of birth interval was 1671 in 2008 and 3290 in 2014, child's weight was 2114 in 2008 and 4196 in 2014.

Source: 2008 and 2014 Ghana Demographic and Health Surveys

In the bi-variable analysis, child's age ($p < 0.001$), gestation ($p = <0.001$) and births order ($p < 0.05$), were associated with mortality of children under-five years old in 2008, while child's age ($p < 0.001$) and gestation ($p < 0.001$) were associated with mortality in 2014. In the combined data set, child's age ($p < 0.001$), birth order ($p < 0.05$) and gestation ($p < 0.001$) were associated with under-five mortality.

4.2 Maternal and Household Factors of Child Factors of Who Died

Regarding socio-economic factors, about 71.1% of children were born to mothers less than 35 years at baseline and 68.6% at end line (Table 7). A greater proportion (44.6%) of mothers had at least secondary education at baseline which increased to 53.9% at end line.

Table 7: Maternal and Household Factors of Children Under-Five Years and Mortality

Year	Baseline (2008)		End line (2014)		Combined	
Characteristics	Total 2045 (98.1%)	Died 40 (1.9%)	Total 4053 (98.8%)	Died 53 (1.2%)	Total 6005 (98.5%)	Died 93 (1.5%)
Had NHIS	751 (89.5)	11 (60.5)	2459 (87.1)	28 (89.5)	3,210 (87.7)	39 (80.2)
Household size						
Less than 6	1099 (57.4)	17 (45.0)	2255 (59.1)	25 (46.1)	3,354 (58.5)	42 (45.6)*
>=6	946 (42.6)	23 (55.0)	1798 (40.9)	28 (53.9)	2,744 (41.5)	51 (54.4)
Region						
Northern belt	676 (22.7)	19 (33.8)	1363 (19.0)	22 (26.1)	2,039 (20.3)	41 (29.5)*
Middle belt	669 (37.6)	12 (38.8)	1221 (36.0)	16 (42.2)	1,890 (36.5)	28 (40.7)
Southern belt	700 (39.6)	9 (27.5)	1469 (45.0)	15 (31.7)	2,169 (43.2)	24 (29.8)
Rural residence	1320 (59.7)	27 (64.8)	2384 (53.8)	35 (61.0)	3,704 (55.8)	62 (62.7)
Wealth quintile						
Poorest	617 (23.2)	18 (33.5)	1279 (21.7)	21 (33.0)	1,896 (22.2)	39 (33.2)
Poorer	450 (22.0)	7 (19.6)	865 (20.1)	14 (24.0)	1,315 (20.8)	21 (22.0)
Middle	348 (18.6)	6 (18.6)	750 (19.6)	8 (16.2)	1,098 (19.3)	14 (17.2)
Richer	368 (20.8)	5 (18.7)	641 (19.6)	6 (16.4)	1,009 (20.0)	11 (17.4)
Richest	262 (15.4)	4 (9.6)	518 (19.1)	4 (10.5)	780 (17.8)	8 (10.1)
Mother's age						
<35	1435 (71.1)	22 (64.9)	2772 (68.6)	34 (66.4)	4,207 (69.5)	56 (65.7)
35 to 49	610 (28.9)	18 (35.1)	1281 (31.4)	19 (33.6)	1,891 (30.5)	37 (34.3)
Maternal education						
None	748 (31.2)	18 (37.1)***	1371 (26.6)	24 (36.7)	2,119 (28.2)	42 (36.9)***
Primary	481 (24.2)	17 (50.6)	824 (19.5)	10 (25.9)	1,305 (21.1)	27 (37.0)
Secondary or higher	816 (44.6)	5 (12.3)	1858 (53.9)	19 (37.4)	2,674 (50.8)	24 (26.1)
Religion						
Orthodox	530 (25.2)	8 (19.7)*	960 (21.7)	12 (23.3)	1,490 (22.9)	20 (21.7)
Pentecostal	851 (46.2)	13 (36.7)	1937 (54.5)	20 (44.3)	2,788 (51.7)	33 (40.9)
Islam	399 (18.2)	9 (18.7)	836 (16.8)	18 (24.7)	1,235 (17.3)	27 (22.0)
Others	265 (10.4)	10 (24.9)	320 (7.0)	3 (7.7)	585 (8.2)	13 (15.4)
Ethnicity						
Akan	793 (46.5)	14 (45.3)	1515 (46.5)	13 (33.7)	2,308 (46.5)	27 (38.9)
Mole-Dagbani	528 (20.4)	13 (20.2)	1090 (17.3)	16 (20.9)	1,618 (18.4)	29 (20.6)
Others(Ga/Dangbe /Eve)	724 (33.1)	13 (34.5)	1448 (36.2)	24 (45.4)	2,172 (35.1)	37 (40.5)
Married	1470 (68.7)	31 (71.7)	2683 (62.7)	32 (55.5)	4,154 (64.7)	63 (62.7)
Polygamous home	386 (19.5)	12 (31.8)	651 (15.2)	12 (24.5)	1,037 (16.7)	24 (28.0)*
Mother's employment status						
Not employed	248 (12.5)	7 (19.5)	811(19.9)	11(22.2)	1,059(17.4)	18(21.0)
Employed	1786 (87.5)	33 (80.5)	3240(80.1)	42(77.8)	5,026(82.6)	75(79.0)
No. of children <5 years in household						
1-2	1769 (86.9)	33 (82.3)	3557 (88.7)	48 (92.2)	5,326 (88.1)	81 (87.8)
3-9	276 (13.1)	7 (17.7)	496 (11.3)	5 (7.8)	772 (11.9)	12 (12.2)
Total	2045 (100)	40 (100)	4,053 (100)	53 (100)	6 005 (100)	93 (100)

*p<0.05. **p<0.01, ***p<0.001

N=total sample. n=number of observations. Sample size of maternal age was 2,161 in 2014, cowives was 1,881 in 2008 and 3,537 in 2014. NHIS was introduced after 2008 and sample size was 2,898 in 2014.

Source: 2008 and 2014 Ghana Demographic and Health Surveys

In the combined data set, 50.8% of mothers had at least secondary education. From the bi-variable analysis, maternal education ($p < 0.001$) and religion ($p < 0.05$) were associated with mortality at baseline, while maternal education ($p < 0.001$), being from a polygamous ($p < 0.05$), number of household members ($p < 0.05$) and region ($p < 0.05$) were associated with mortality in the combined data set.

4.3 Intervention Use Among Children Under-Five Years Who Died

Antenatal coverage level was the highest among the interventions both at base line and end line (Table 8).

Table 8: Coverage of Interventions by Mortality among Children Under-Five Years

Year	Baseline (2008)		End line (2014)		Combined	
Intervention	Total n (%)	Died n (%)	Total n (%)	Died n (%)	Total n (%)	Died n (%)
Water <30minutes	445 (22.5)	6 (17.0)	2813 (64.2)	41 (72.7)	4,413 (68.7)	75 (76.0)
Water connected	175 (9.7)	2 (17)	294 (7.3)	6 (11.8)	4,69 (8.1)	8 (7.3)
Improved sanitation	156 (7.8)	4 (8.7)	404 (11.6)	4 (5.3)	560 (10.3)	8 (6.9)
Hygienic disposal of stool	918 (46.9)	5 (11.2)	1474 (39.4)	15 (33.2)	2,392 (42.0)	20 (23.4)**
Antenatal visit	1565 (78.2)	24 (68.4)	3480 (87.0)	42 (83.1)	5,045 (84.0)	66 (76.5)
IPTp	830 (41.0)	18 (46.2)	2828 (69.3)	35 (70.3)	3,658 (59.7)	53 (59.5)
Iron(90day+)	781 (41.2)	16 (46.4)	2266 (59.3)	29 (57.9)	3047 (53.2)	45 (52.8)
TT protected	1416 (70.9)	28 (71.6)	3099 (79.0)	36 (69.1)	4,515 (76.3)	64 (70.2)
Health facility delivery	1153 (60.0)	21 (63.3)	2894 (74.7)	33 (64.7)	4047 (69.7)	54 (64.1)
Skilled delivery	1183 (61.5)	22 (67.5)	2926 (75.4)	33 (64.7)	4,109 (70.7)	55 (66.0)
Contraceptives use	468 (23.3)	7 (21.1)	1179 (29.9)	10 (21.6)	1,647 (27.7)	17 (21.3)
Clean postnatal	143 (6.4)	1 (0.9)*	1010 (23.3)	10 (13.4)	1,153 (17.6)	11 (7.8)*
Early Breastfeeding	1,082 (51.7)	11 (24.6)**	2245 (54.8)	18 (31.4**)	4,152 (66.7)	39 (39.7)***
Household ITN/IRS	1493 (71.1)	26 (59.1)	3491 (83.6)	45 (84.4)	4,984 (79.4)	71 (73.1)
8 interventions	0 (0.0)	0 (0.0)	58 (2.1)	0 (0.0)	58 (1.4)	0 (0.00)
Total	2045 (100)	40 (100)	4053 (100)	53 (100)	6005 (100)	93 (100)

*p<0.05. **p<0.01, ***p<0.001. n=number of observations. These eight interventions were antenatal visit, IPTp, iron (90day+), protection from neonatal tetanus, skilled delivery, clean postnatal care, early initiation of breastfeeding and household ITN/IRS coverage.

Source: 2008 and 2014 Ghana Demographic and Health Surveys

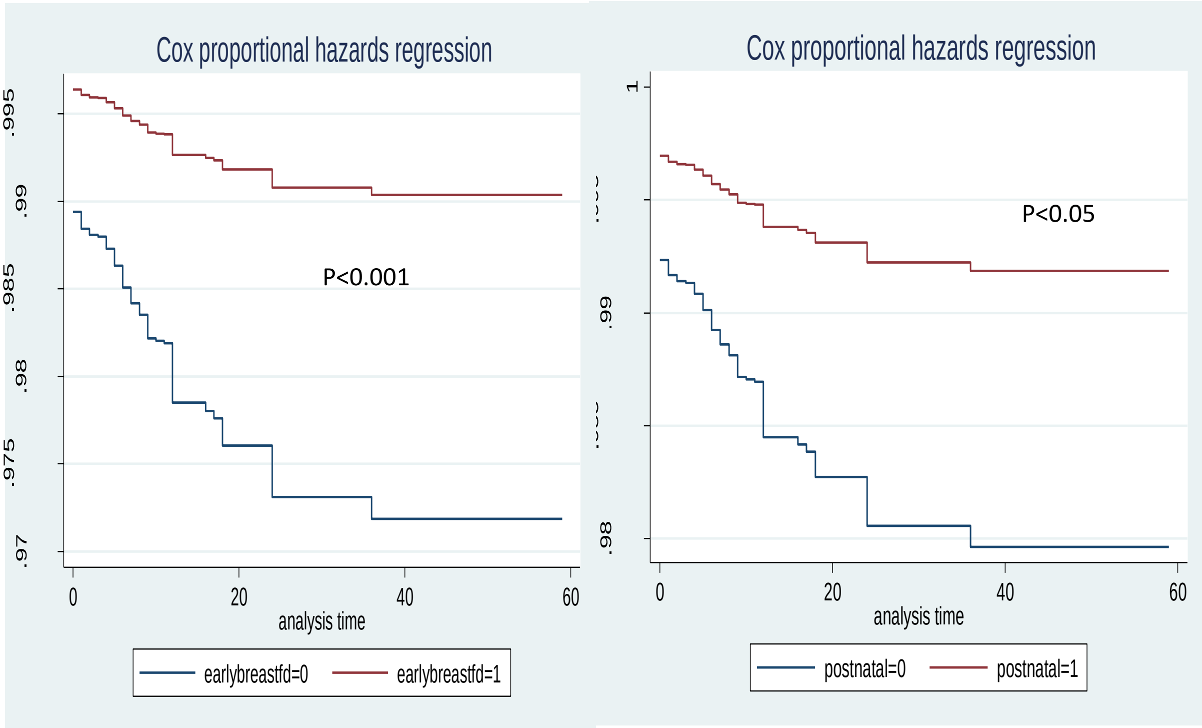
At baseline, about 78.2% of mothers had attended four or more antenatal visits. At end line, 87.0% attended at least four antenatal visits, while 84.0% did so in the combined data set (Table 8). The interventions with the lowest coverage levels were improved sanitation and water connection in the home. Coverage level of improved sanitation was 6.9%, while that of water connection in the home was 7.3% in the combined data set. About 1.4% of children received all the eight (8) interventions and none of those who received all the eight interventions died. From the bi-variable analysis, early initiation of breastfeeding ($p < 0.001$), hygienic disposal of stool ($p < 0.01$) and clean postnatal care ($p < 0.05$) were associated with mortality from the combined data set.

4.4 Impact of Intervention on Under-Five Mortality

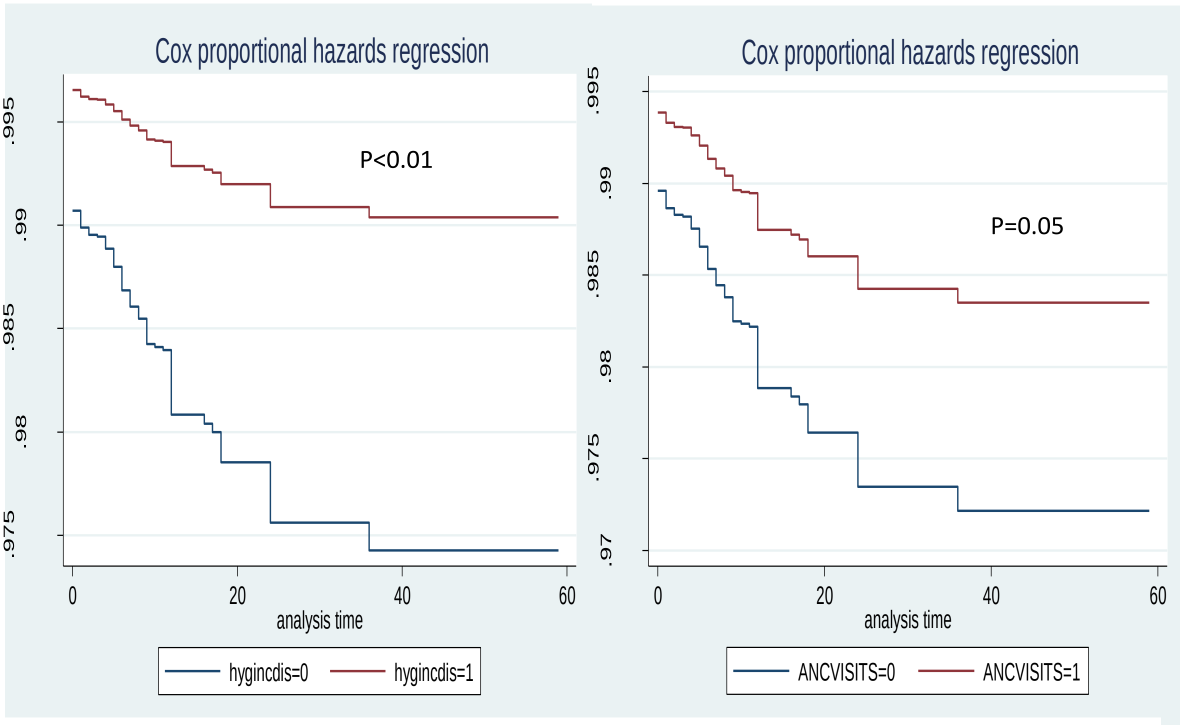
Concerning the effect of interventions on child survival, survival graphs, odds and rate of death were estimated at the individual level. At the population level, the contribution of the interventions to lives saved and mortality rate reduction were estimated and are presented in this section.

4.5 Effect of Interventions on Child Survival

Using survival analysis, survival graphs of the interventions are presented in Figure 8. Survival was better for those with early initiation of breastfeeding ($p < 0.001$), clean postnatal care ($p < 0.05$) and hygienic disposal of stool ($p < 0.01$).



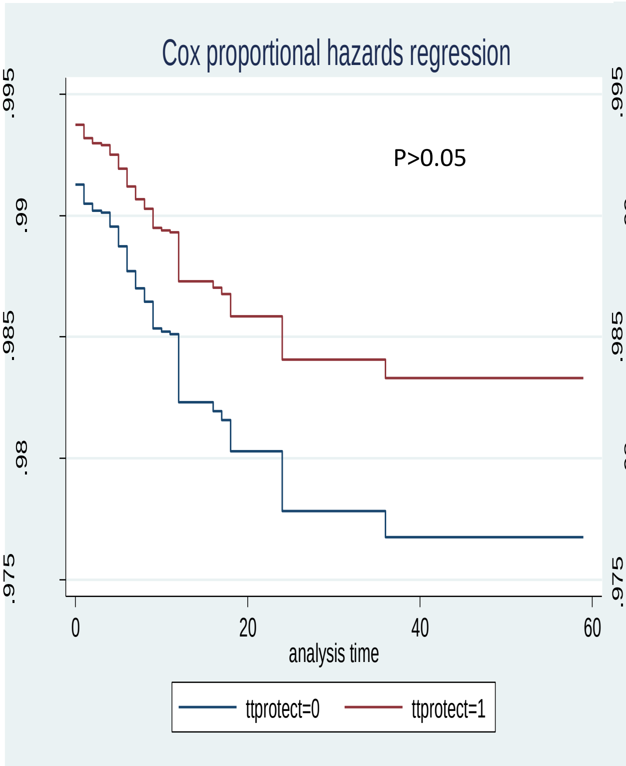
Early initiation of breastfeeding (within 1 hour) Clean postnatal care (within 2 days)



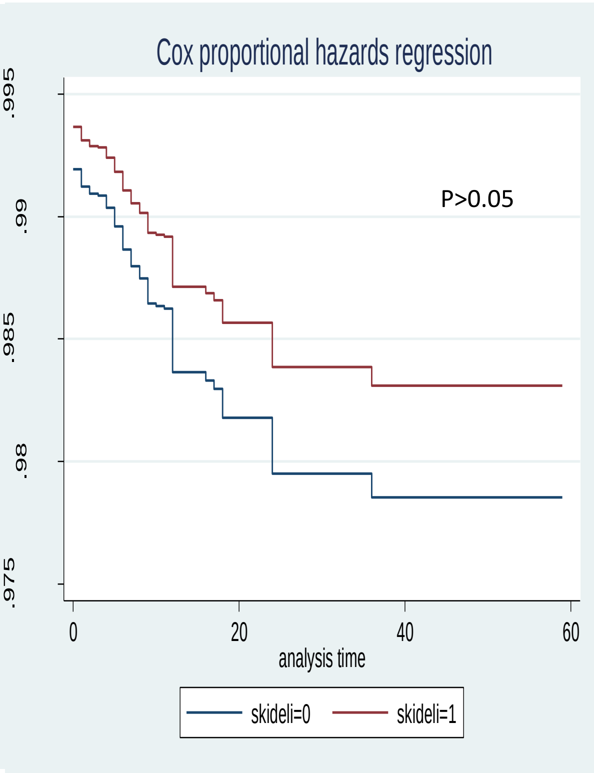
Hygienic disposal of stool Antenatal care visits (4 plus visits)

Figure 8: Effect of Interventions on Child Survival

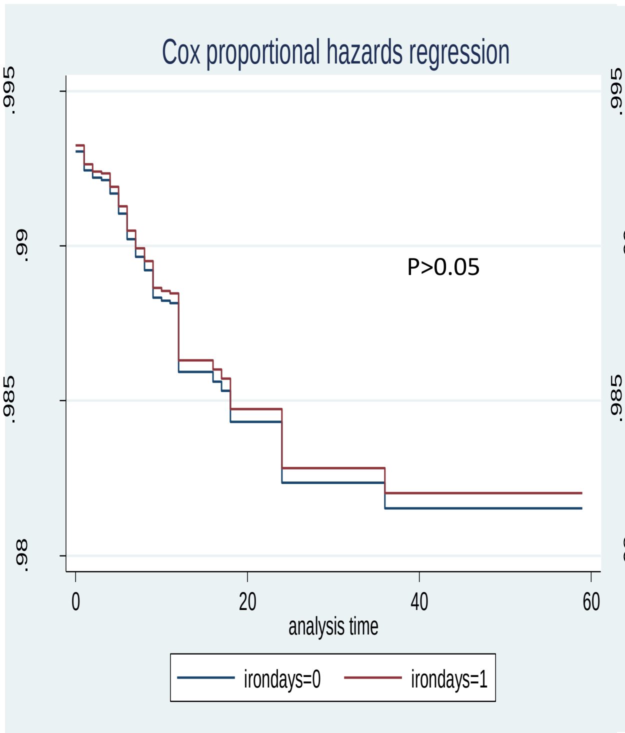
Source: 2008 and 2014 Ghana Demographic and Health Surveys



Tetanus toxoid vaccination



Skilled delivery



Iron intake (for at least 90 days)

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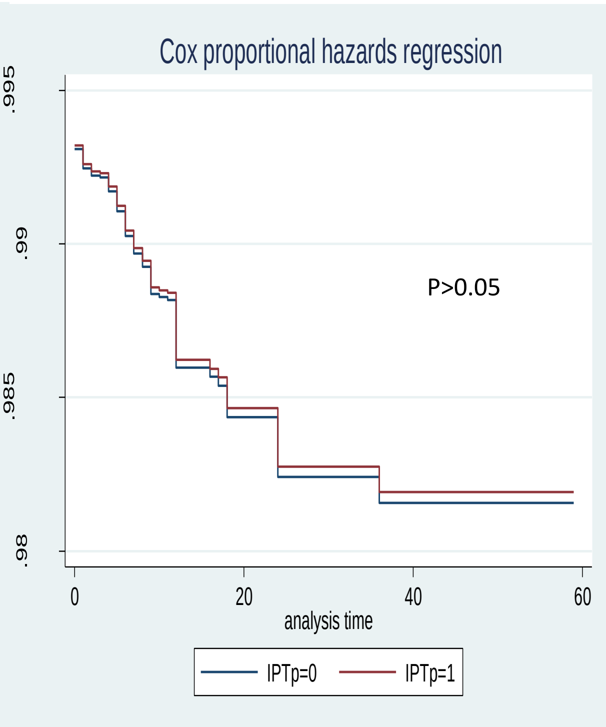

Intermittent preventive treatment of malaria in pregnancy (at least 2 doses)

Figure 8 continued: Effect of Interventions on Child Survival

Source: 2008 and 2014 Ghana Demographic and Health Surveys

4.6 Effectiveness of interventions on under-five mortality reduction at the individual level

The crude and adjusted odds ratios (ORs) and incidence rate ratios (IRRs) of the effect of the eight (8) interventions mortality are presented in Table 9.

Table 9: Interventions with Causal Effect on Under-5 Mortality between 2003 and 2014

	Logistic regression		Poisson regression	
Intervention	OR(95%CI)	aOR (95%CI)	IRR	aIRR
Early initiation of breastfeeding (within 1 hour)	0.34 (0.20-0.55)***	0.42 (0.23-0.75)**	0.35 (0.21-0.58)***	0.49 (0.29- 0.80)*
Clean postnatal care (within 2 days)	0.41 (0.20-0.83)*	0.41 (0.19-0.86)*	0.41 (0.20-0.83)*	0.40 (0.18-0.86)*
IPTp-SP (at least 2 doses)	2.36 (1.30-4.29)*	2.77 (1.26-6.10)*	2.34 (1.29-4.24)*	2.35 (1.26-4.39)*
Tetanus toxoid vaccination	1.38 (0.62-3.05)	1.17 (0.52-2.65)	1.19 (0.54-2.60)	0.94 (0.42-2.11)
Hygienic disposal of stool	0.61 (0.31-1.17)	0.79 (0.34-1.83)	0.42 (0.22-0.80)*	0.81 (0.39-1.71)
Skilled delivery	0.57 (0.18-1.78)	0.81 (0.42-1.58)	0.50 (0.17-1.50)	0.89 (0.57-1.37)
Iron intake (for 90 days)	1.52 (0.83-2.79)	1.69 (0.83-3.44)	1.60 (0.87-2.96)	1.88 (0.94-3.72)
Antenatal care visits (4 plus visits)	1.17 (0.51-2.69)	0.99 (0.45-2.19)	1.08 (0.44-2.64)	0.87 (0.39-1,95)

*p < 0.05. **p < 0.01, ***p < 0.001
Source: 2008 and 2014 Ghana Demographic and Health Surveys

From the logistic regression crude analysis, odds of death was reduced by 66% among those with early initiation of breastfeeding (OR = 0.34, 95% CI: 0.2 - 0.55, $p < 0.001$) and 59% among those who had clean postnatal care within 2 days (OR = 0.41, 95%CI: 0.20 - 0.83, $p < 0.05$). Intermittent preventive treatment of malaria in pregnancy with two or more doses of sulphadoxine pyremethamine (SP) increased the odds of death 2.4 times (OR = 2.36, 95% CI: 1.30 - 4.29, $p < 0.05$). After adjusting for potential confounders, early initiation of breastfeeding reduced odds of death by 58% (aOR = 0.42, 95% CI: 0.23 - 0.75, $p < 0.01$), while clean postnatal care caused a 59% reduction in the odds of death (aOR = 0.41, 95%CI: 0.19 - 0.86, $p < 0.05$). For children whose mothers received at least two doses of IPTp, the treatment effect was a 2.8 times higher odds of death (aOR = 2.77, 95% CI: 1.26 - 6.10, $p < 0.05$) after controlling for potential confounders.

From the Poisson regression crude analysis, incidence rate of death was reduced by 65% among those with early initiation of breastfeeding (IRR = 0.35, 95% CI: 0.21 - 0.58, $p < 0.001$), 59% among children under-five years who had clean postnatal care within 2 days (IRR = 0.41, 95%CI: 0.20-0.83, $p < 0.05$) and 58% among those with hygienic disposal of stool (IRR = 0.42, 95%CI: 0.22 - 0.80, $p < 0.05$). Intermittent preventive treatment of malaria in pregnancy with two or more doses of SP increased the odds of death 2.3 times (IRR = 2.34, 95% CI: 1.29 - 4.24, $p < 0.05$). After adjusting for potential confounders, early initiation of breastfeeding reduced the rate of death by 51% (a IRR = 0.49, 95% CI: 0.29-0.80, $p < 0.05$) while clean postnatal care caused a 60% reduction in the rate of death (a IRR = 0.40, 95%CI: 0.18, 0.86, $p < 0.05$). For children whose mothers received at least two doses of IPTp, the treatment effect was a 2.4 times higher odds of death (a IRR = 2.35, 95% CI: 1.26 - 4.39, $p < 0.05$) after controlling for potential confounders.

4.7 Contribution of interventions to lives saved and mortality rate reduction at the population level

At the population level, a total of 42,426 lives were saved resulting in a 78% mortality rate reduction from changes in the coverage levels of interventions, as well as reduction in the prevalence of stunting and wasting among children born between 2003 and 2014 (Table 10).

Table 10: Impact of Interventions (Additional Child Lives Saved and Mortality Reduction) by Intervention between 2003 and 2014 among Children 0-59 Months

Type of nutrition modeling	Intervention coverage		Intervention based modeling		Direct entry of stunting& wasting	
Intervention/risk factor	2008 (%)	2014 (%)	Lives saved	Percent mortality reduction attributable to intervention (%)	Lives saved	Percent mortality reduction attributable to intervention (%)
Pregnancy						
Tetanus vaccination	71.1.0	78.8	236	1	236	0
IPTp	45.5	67.7	323	1	308	1
Childbirth						
Skilled delivery	57.1	73.7	4,726	12	4,726	8
Breastfeeding						
Age-appropriate breastfeeding practices	NA	NA	-2,018	-5	-2,083	-4
Preventive						
Clean postnatal care	6.5	23.3	1275	3	1,273	2
Vitamin A supplementation	69.6	64.3	-306	0	-290	-1
Improved water source and	67.2	48.8				
Improved sanitation	11.2	13.6	166	0	153	0
Water connection in the home	14.2	9.7	-706	0	-661	-1
ITN/IRS	45.4	72.7	8,538	22	8,524	16
Complementary feeding reduction in stunting)	46.7	27.8	-457	-1	NA	NA
Complementary feeding reduction in wasting)	46.7	27.8	-62	0	NA	NA
Change in stunting	27.5	18.8	NA	NA	5,761	11
Change in wasting	8.5	4.7	NA	NA	11,918	19
Vaccines						
DPT vaccine	85.7	87.9	358	1	358	1
*Haemophilus influenza*e type B	85.7	87.9	1,358	3	1,325	2
Pneumococcal	0	84.2	2,430	11	2,406	8
Rota virus	0	87.6	1,045	5	1,033	3
Measles	86.6	88.1	134	0	126	0
Curative after birth						
Oral rehydration salts	44.5	48.7	1,143	3	1,038	2
Antibiotics for dysentery	46.4	42.4	-140	0	-142	0
Zinc for treatment of diarrhea	1.8	7.4	254	1	230	0
Oral antibiotics for pneumonia	50.7	52.6	529	1	485	1
ACTs	11.3	26.2	5,688	14	5,702	10
Total			24,514	72	42,426	78

NA=Not applicable

Source: 2008 and 2014 Ghana Demographic and Health Surveys

Interventions that saved the most lives among children under-five years were insecticide treated net and or indoor residual spraying (ITN/IRS) (8,524 lives saved, 16% mortality rate reduction), artemisinin-based combination therapy (ACTs) (5,702 lives saved, 10% mortality rate reduction), labour and delivery management (4,726 lives saved, 8% mortality rate reduction) and pneumococcal vaccine (2,406 lives saved, 8% mortality rate reduction). Reduction in wasting saved 11,918 lives and contributed to a 19% reduction of mortality, while reduction in the prevalence of stunting also saved 5,761 lives and contributed to an 11% reduction in under-five mortality rate.

However, complementary feeding targeted at reducing mortality via reduction in stunting (-457 lives saved, -1% mortality rate reduction) and wasting (-62 lives saved, 0% mortality rate reduction) resulted in negative lives being saved (excess deaths/additional deaths) between 2008 and 2014 from the modelling of only interventions. Water connection in the home (-661 lives saved, -1% mortality rate reduction) and vitamin A supplementation (-290 excess death, 1% mortality rate reduction) also resulted in negative lives saved (excess deaths) when the effect of stunting and wasting were considered. The intervention with the most additional deaths between 2008 and 2014 was breastfeeding (-2,083 lives saved, -4% mortality rate reduction).

It can be seen from Table 11 that at 90% coverage of each intervention, one at a time, labour and delivery management (9,764) and clean postnatal care (1,576 lives saved) would have saved the most lives among neonates. Among children 1-59 months, ACTs (5,498 lives saved), ORS (2,148 lives saved), water connection in the home (2,011 lives saved), antibiotics for the treatment of pneumonia (1,900 lives saved) and ITN/IRS (1,032 lives saved) would have made the greatest impact on mortality reduction.

Table 11: Impact of Scaling Up Interventions to 90% Coverage at the Population Level among Children 0-1 Month and 1-59 Months

Age group	Less than 1 month old	1 to 59 months old	Baseline (2014) coverage level 2014 coverage level
Labor and delivery management at the CEmOC level	6,112	0	43.8
Labor and delivery management at the BEmOC level	2,592	0	11
ACTs	0	5,498	26.2
ORS	68	2,148	48.6
Labor and delivery management at the Essential care level	1,060	0	18.3
Water connection in the home	59	2,011	18.9
Oral antibiotics for pneumonia	0	1,900	52.6
Clean postnatal care	1,576	0	22.9
ITN/IRS	80	1,032	70.9
IPTp	96	3	67.7
Improved sanitation	12	401	13.6
Zinc for treatment of diarrhea	21	671	7.4
Breastfeeding	106	489	50
Vitamin A supplementation	0	242	64.3
Antibiotics for treatment of dysentery	8	249	42.4
Tetanus vaccination	96	0	78.8
HiB	0	128	87.9
Pneumococcal vaccine	0	125	84.2
DPT vaccine	0	45	87.9
Rota virus vaccine	0	13	87.6

CEmOC=comprehensive emergency obstetric care. BEmOC=basic emergency obstetric care
Source: 2008 and 2014 Ghana Demographic and Health Surveys

4.8 Under-five mortality at hundred percent coverage of all 24 interventions at the population level

If coverage levels of all the twenty-four (24) interventions were scaled up to 100% in 2014, neonatal mortality rate would have been 14 deaths per 1,000 live births, stead of 29/1,000 live births, an additional mortality rate decline of 51.7%. Under-five mortality rate would have also been 36 deaths per 1,000 live births, instead of 60/1,000 live births in 2014, an additional decline of 40.0%. This would have also translated into an annual neonatal mortality rate decline of 1.8/ 1,000 live births and an annual under-five mortality rate decline of 3.7/1,000 live births from 2008 to 2014.

4.9 Factors associate with under-five mortality between 2003 and 2014

On factors associated with under-five mortality, results from the simple logistic regression showed that child's age, birth order, multiple birth, maternal education, region, polygamous home, household size, NHIS status, clean postnatal care within two days and hygienic disposal of stool were associated with death of children under-five years. Odds of deaths was 98% lower among children 1-5 months (OR=0.02, 95% CI: 0.01, 0.05), 97% lower among those 6-11 months (OR=0.03, 95% CI: 0.01, 0.06) and 99% among those 12 months and above (OR=0.01, 95% CI: 0.004, 0.02) compared to those less than one month and this was statistically significant, $p < 0.001$. Clean postnatal care reduced odds of death by 61% (OR=0.39, 95%CI: 0.20-0.78, $p < 0.05$), while hygienic disposal reduced odds of death by 58% (OR=0.42, 95%CI: 0.23-0.74, $p < 0.01$). Additionally, odds of death reduced by 61% among children whose mothers had NHIS (OR=0.39, 95%CI: 0.17, 0.87, $p < 0.05$). Lastly, compared to children from the northern belts of Ghana, odds of death was reduced by 24% (OR=0.76, 95% CI: 0.45-1.30) among those in the middle belts and 53% (OR=0.47, 95% CI: 0.26-0.83), $p < 0.05$ among those in the southern belt.

Among the factors associated with higher odds of death, children who were multiple births were 5 times more likely to die (OR=4.52, 95% CI: 2.07-9.89, $p < 0.001$) compared to those who were singleton.

Table 12: Unadjusted and Adjusted Odds Ratios of Factors Associated with Under-Five Mortality among Children 0-59 Months (2008 And 2014 Pooled Data), Logistic Regression

Characteristics	OR (95% CI)	aOR(95% CI)
Survey year		
2008		
2014	0.63 (0.40, 0.60)	0.67(0.37, 1.21)
Age(months)		
<1		
1 to 5	0.02(0.01, 0.05)***	0.02(0.01, 0.04)***
6 to 11	0.03(0.01, 0.06)	0.02(0.01, 0.04)
12 and above high	0.01(0.004, 0.02	0.005(0.002, 0.01)
Gender		
Male		
Female	0.90(0.57, 1.41)	0.98(0.55, 1.74)
Birth interval		
>=2 years		
Less than 2	1.88(0.94, 3.76)	1.95(0.96, 3.95)
Birth order		
Below 3		
>= 3	1.93(1.21, 3.09)*	1.84(0.88, 3.84)
Birth weight		
Normal		
Small	1.26(.67, 2.37)	0.93(0.39, 2.22)
Multiple birth		
Singleton		
Multiple birth	4.52(2.07, 9.89)***	5.40(1.27, 22.99)*
Delivery type		
Vaginal		
Caesarean	1.09(0.50, 2.41)	0.76(0.29, 1.96)
Region		
Northern belt		
Middle belt	0.76(0.45, 1.30)*	1.02(0.42, 2.49)
Southern belt	0.47(0.26, 0.83)	0.67(0.23, 1.94)
Urban/rural		
Urban		
Rural	1.34(0.82, 2.18)	0.86(0.35, 2.07)
Wealth quintile		
Poorest		
Poorer	0.70(0.37- 1.33)	0.70(0.25, 1.98)
Middle	0.59(0.29- 1.19)	0.85(0.26, 2.79)
Richer	0.58(0.27-1.22)	0.64(0.15, 2.85)
Richest	0.37(0.15-0.94)	0.88(0.17, 4.71)
Polygamous home		
Not polygamous		
Polygamous	1.91(1.12-3.24)*	2.33(1.23, 4.42)*
Household size		
<6		
>=6	1.70(1.06, 2.72)*	1.05(0.49-2.25)
No. of CU5 in household		
1-2		
3 and above	1.03(0.52-2.04)	0.19(0.07-0.49)**
Maternal age		
<35		
>=35	1.19(0.73-1.93)	0.79(0.39-1.62)
Marital status		
Not Married		
Married	0.92(0.56-1.50)	0.64(0.31-1.32)

Table 12: Unadjusted and Adjusted Odds Ratios of Factors Associated with Under-Five Mortality, Logistic Regression Continued

Characteristics	OR (95% CI)	aOR(95% CI)
Maternal education		
None		
Primary	1.35(0.78- 2.34)***	1.09(0.46-2.55)
Secondary or higher	0.39(0.22- 0.70)	0.52(0.20-1.36)
Religion		
Orthodox		
Pentecostal	0.83(0.45, 1.55)	0.91(0.43-1.92)
Islam	1.35(0.67, 2.72)	1.21(0.49-3.02)
Others	2.02(0.90, 4.55)	0.92(0.27-3.10)
Ethnicity		
Akan		
Mole-Dagbani	1.35(0.74-2.45)	0.69(0.20-2.33)
Others (Ewe, Ga)	1.39(0.80-2.40)	1.29(0.57-2.91)
Mother's employment		
Not employed		
Employed	0.21(0.13-1.1)	0.76(0.35-1.63)
Contraceptives use		
No use		
Use	0.71(0.38-1.30)	1.30(0.58-2.91)
Sanitation		
Not improved		
Improved	0.64(0.29-1.38)	0.78(0.30-2.05)
Antenatal visits		
<4plus visits		
4 + visit	0.61(0.36-1.04)	0.83(0.39-1.76)
Tetanus toxoid vaccine		
Not received		
Received	0.73(0.44-1.21)	0.75(0.38-1.48)
Skilled delivery		
Not skilled		
Skilled	0.80(0.49-1.32)	1.29(0.56-2.98)
Improved water source		
Not improved		
Improved	1.45(0.82-2.55)	1.38(0.64-2.97)
Water connected		
Not connected		
Connected	0.89(0.35-2.26)	0.92(0.25-3.35)
ITN/IRS protection		
Not protected		
Protected	0.70(0.41-1.20)	0.82(0.39-1.73)
Hygienic disposal of stool		
Not hygienic		
Hygienic	0.42(0.23-0.74)**	0.65(0.35-1.21)
Clean postnatal care in 2days		
No clean postnatal		
Clean postnatal	0.39(0.20-0.78)*	0.46(0.19-1.10)
Iron intake >90 days		
No iron intake		
Iron intake	0.98(0.62-1.55)	1.49(0.76-2.92)
Early breastfeeding		
Not early		
Early	1.20(0.33-2.76)	0.40(0.21-0.75)***
IPTp		
No IPTp		
IPTp	0.99(0.62-1.58)	1.42(0.75-2.72)
NHIS status		
Not covered		
Covered	0.39(0.17-0.87)*	0.20(0.07-0.56)*

*p<0.05. **p<0.01, ***p<0.001. Source: 2008 and 2014 Ghana Demographic and Health Surveys.

Children of third or higher birth order were 2 times likely to die (OR=1.93, 95% CI: 1.21-3.09, $p < 0.05$) relative to those with lower birth order. On educational status of mothers, compared to mothers without education, odds of death was 1.4 times among those with primary education (OR = 1.35, 95% CI: 0.78 - 2.34) but odds of death reduced by 61% (OR = 0.39, 95% CI: 0.22 - 0.70) among those with a minimum of secondary education and this association was statistically significant $p < 0.001$. Additionally, children from polygamous homes were 2 times more likely to die relative to those from monogamous homes (OR = 1.91, 95% CI: 1.12 - 3.24, $p < 0.05$). Lastly, children in households with six or more members had 2 times higher odds of death (OR = 1.70, 95% CI: 1.06 - 2.72, $p < 0.05$) compared to those in households with fewer members.

From the multiple regression model, compared to children less than one month old, odds of death was reduced by 98% (aOR =0.02, 95%CI: 0.01-0.04) among children 1-5 months, also 98% among those 6-11 months (aOR = 0.02, 95% CI: 0.01 - 0.04) and over 99% among those 12 - 59 months (aOR = 0.005, 95%CI: 0.005 - 0.01) and the results were statistically significant $p < 0.001$ (Table 12). On household factors, children in households with 3 or more children under-five years had their odds of death reduced by 81% (aOR =0.19, 95% CI: 0.07 - 0.49, $p < 0.01$) compared to those in households with one or two children under five years old. Additionally, odds of death was reduced by 80% among children whose mothers had health insurance coverage (aOR = 0.20, 95% CI: 0.07 - 0.56, $p < 0.05$) and 60% (aOR = 0.40, 95% CI: 0.21 - 0.75, $p < 0.001$) among children with early initiation of breastfeeding (within 1 hour after birth). However, children who were multiple births were 5 times more likely to die compared to singleton births (aOR=5.4, 95% CI: 1.27-22.99). Also, children in polygamous homes were 2 times likely to die compared to children in monogamous homes (aOR=2.33, 95% CI: 1.23-4.42). Variables in the multiple regression model included sex, child's weight, birth interval and order, multiple birth, maternal age and education, marital status, contraception use, household size, region, area of residence, wealth and improved sanitation. Other were ITN/IRS, skilled delivery, survey year, time to improved water source, religion, ethnicity, number of cowives, caregiver employment status, survey year and NHIS status.

From the adjusted Poisson regression, multiple birth, clean postnatal care, hygienic disposal of stool and early initiation of breastfeeding were associated with mortality as presented in Table 13. Among children who had early initiation of breastfeeding, incidence rate of death was reduced by 60% (IRR=0.40, 95%CI: 0.2-0.6, $p < 0.001$). Those with hygienic disposal of stool experience a 60% reduction in the incidence rate of death (IRR = 0.40, 95% CI: 0.2-0.8, $p < 0.05$), while those with clean postnatal care their rate of death reduced by 60% (IRR = 0.40, 95%CI: 0.2-0.8, $p < 0.05$). Multiple births had 4 times the rate of death of those who were singleton births (IRR = 3.7, 95% CI: 1.5-9.4, $p < 0.05$) was associated with increased risk of death. Variable in the adjusted model were sex of child, child's weight, birth interval, birth order, multiple birth, maternal age and education, marital status, contraception use, household size, region, area of residence, wealth and improved sanitation. Other were ITN/IRS, skilled delivery, time to improved water source, religion, ethnicity, number of cowives, caregiver employment status, survey year and NHIS status.

Table 13: Unadjusted and Adjusted Odds Ratios of Factors Associated with Under-Five Mortality among Children 0-59 Months (2008 And 2014 Pooled Data), Poisson Regression

Characteristics	IRR(95% CI)	aIRR(95% CI)
Survey year		
2008		
2014	0.6(0.4-0.1)	0.7(0.4-1.1)
Gender		
Male		
Female	0.9(0.6-1.4)	0.9(0.6-1.5)
Birth interval		
Less than 2		
>=2 years	1.9(0.9-3.7)	1.9(0.9-3.8)
Birth order		
Below 3		
>= 3	1.9(1.2-3.0)*	1.7(0.9-3.1)
Birth weight		
Normal		
Small (<2.5kg)	1.3(0.7-2.3)	1.1(0.5-2.1)
Gestation		
Singleton birth		
Multiple birth	4.3(2.1-9.1)***	3.7(1.5-9.4)*
Delivery type		
Vaginal		
Caesarean	1.1(0.5-2.2)	0.9(0.4-2.4)
Region		
Northern belt		
Middle belt	0.8(0.5-1.3)*	0.9(0.4-1.8)
Southern belt	0.5(0.3-0.8)	0.6(0.3-1.6)
Urban/rural		
Urban		
Rural	1.3(0.8-2.2)	1.0(0.5-1.9)
Maternal education		
None		
Primary	1.3(0.8-2.3)***	1.8(0.9-3.4)
Secondary or higher	0.4(0.2-0.7)	0.6(0.3-1.4)
Wealth quintile		
Poorest		
Poorer	0.7(0.4-1.3)	0.9(0.4-1.9)
Middle	0.6(0.3-1.2)	0.8(0.3-2.1)
Richer	0.6(0.3-1.2)	1.1(0.4-3.2)
Richest	0.4(0.2-0.9)	0.9(0.2-3.4)
Maternal age		
< 35		
>=35	1.2(0.7-1.9)	0.7(0.4-1.3)
Household size		
<6		
>=6	1.7(1.1-2.7)*	1.4(0.8-2.5)
No. of CU5 in household		
1-2		
3 and above	1.0(0.5-2.0)	0.5(0.2-1.0)
Religion		
Orthodox		
Pentecostal	0.8(0.5-1.5)	0.8(0.4-1.6)
Islam	1.3(0.7-2.7)	0.8(0.4-1.7)
Others	2.0(0.9-4.4)	1.0(0.4-2.4)

Table 14: Unadjusted and Adjusted Odds Ratios of Factors Associated with Under-Five Mortality, Poisson Regression Continued

Characteristics	IRR(95% CI)	a IRR(95% CI)
Married		
Not married		
Married	0.9(0.6-1.5)	0.8 (0.4-1.4)
Ethnicity		
Akan		
Mole-Dagbani	1.3(0.7-2.4)	0.9 (0.3-2.3)
Others (Ewe, Ga)	1.4(0.8-2.4)	1.2(0.6-2.3)
Polygamous home		
Not polygamous		
Polygamous	1.9(1.1-3.2)*	1.5 (0.9-2.7)
Employment status		
Not employed		
Employed	0.8(0.4-1.4)	0.7(0.4-1.2)
NHIS status		
Not covered		
Covered	0.5(0.2-0.9)	0.5(0.2-1.1)
Antenatal visits		
Less than 4plus		
Four plus visits	0.6(0.4-1.0)	0.8(0.5-1.4)
Contraceptives use		
No use		
Use	0.7(0.4-1.3)	0.7(0.4-1.3)
Sanitation		
Not improved		
Improved	0.6(0.3-1.4)	1.1(0.4-2.7)
Tetanus vaccine		
Not received		
Received	0.7(0.4-1.2)	0.8 (0.5-1.5)
Skilled delivery		
Not skilled		
Skilled	0.8(0.5-1.3)	1.4(0.7-3.0)
Water in 30min		
No water in 30mins		
Water in 30 minutes	1.4(0.8-2.5)	1.2(0.6-2.4)
Water connected		
Not connected		
Connected	0.9(0.4-2.2)	0.9(0.2-3.2)
ITN/IRS protection		
Not protected		
Protected	0.7(0.4-1.2)	0.8(0.5-1.4)
Hygienic disposal of stool		
Not hygienic		
Hygienic	0.4(0.2-0.7)**	0.4(0.2-0.8)*
Clean postnatal		
No clean postnatal		
Clean postnatal	0.4(0.2-0.8)*	0.4(0.2-0.8)*
Iron intake >90 days		
No iron intake		
Iron intake	1.0(0.6-1.5)	1.4(0.8-2.3)
Early breastfeeding		
Early		
Not early	0.3(0.2-0.6)***	0.4(0.2-0.6)***
IPTp		
No IPTp		
IPTp	1.0(0.6-1.6)	1.3(0.8-2.2)

Source: 2008 and 2014 Ghana Demographic and Health Surveys

4.10 Summary of results

The results from this study have been summarised as:

1. Child survival was higher when there was early initiation of breastfeeding, clean postnatal care and hygienic disposal of stool.
2. From the eight interventions assessed at the individual level, early initiation of breastfeeding and clean postnatal care contributed to a reduction in mortality, while IPTp-SP contributed to an increase in mortality.
3. At the population level, malaria control interventions (ITN/IRS and ACTs), vaccines (pneumococcal, haemophilus type B and rota virus vaccines), skilled delivery and reduction in the prevalence of stunting and wasting made the most impact during the period of the evaluation.
4. Additionally, if interventions coverage levels had increased to 90%, among neonates, skilled delivery and clean postnatal care would have made the most impact. Among children 1-59 months, ACTs, ORS, water connection in the home and antibiotics for treatment of pneumonia would make the most impact.
5. It is worth noting that, had all the 24 interventions been scaled up to 100%, Ghana would have reduced its neonatal mortality and under-five mortality statistics further by approximately 51% and 40% respectively between 2008 and 2014.
6. Lastly, in the midst of these interventions, some socio-demographic factors remained associated with under-five mortality. Being a neonate, multiple birth or from a polygamous home increased odds of death, while belonging to a home with three or more children under-five years or a mother who had health insurance coverage reduced odds of death.

CHAPTER FIVE

DISCUSSION

Under-five mortality remains a global challenge despite the existence of many interventions, in several countries including Ghana, targeted at reducing it (Liu et al., 2016; United Nations, 2015). These interventions are been implemented because they have shown evidence of ability to reduce under-five deaths (Bhutta et al., 2013). Although these interventions have been implemented because of established effect on reducing mortality under experimental conditions, their effectiveness (effect in real life situation) might be suboptimal. Ghana is implementing these child health interventions, but mortality decline is slow resulting in none achievement of the Millennium Development Goal 4 (MDG4) (Schieber et al., 2012). What was not known was the intervention(s) that contributed to mortality decline between 2003 and 2014 in Ghana. This study therefore, sought to evaluate the impact of the various maternal, neonatal, child health and nutrition (MNCHN) interventions on under-five mortality in Ghana. These interventions included tetanus toxoid vaccine, clean postnatal care, water connection in the home, time to improved water source, intermittent preventive treatment of malaria in pregnancy (IPTp) and skilled delivery.

5.1 Characteristics of Children who Died and Factors Associated with Mortality Between 2003 and 2014

In this study, children who died were mostly neonates, multiple births, children of third or higher birth order and children from the northern belt of Ghana. In addition to these socio-demographic factors, children without hygienic disposal of stool, clean postnatal care and early initiation of breastfeeding also died disproportionately. Of these characteristics of children that put them at lower chances of survival, being a neonate and being a multiple birth were associated with under-five mortality from the regression analysis. The relationship between these factors and under-five deaths have been documented (Das et al., 2013; Geldsetzer et al., 2014; Keats et al., 2017; Shifa et al., 2018; United Nations, 2015).

Of much concern among these is neonatal deaths. In this study, although neonates formed 1.8% of the children under-five years, they formed 47.0% of those who died and the proportion of neonatal deaths increased from 46.0% to 47.8% between 2008 and 2014. Neonates are less developed, more susceptible to infections and require specialized and advanced care which is usually not available especially in poverty ridden settings (Liu et al., 2016). In Ghana, there are issues with access to, and quality of their care (Nesbitt et al., 2013). According to Kruk et al. (2018), neonatal mortality ranked second in deaths due to poor quality of care.

Considering the causes of neonatal deaths such as sepsis, diarrhoea, pneumonia and asphyxia, quality skilled delivery and improved nutrition and sanitation will play important roles in neonatal mortality reduction (Liu et al., 2016). However, coverage levels of sanitation interventions are among the interventions with the lowest coverage levels, while the quality of skilled delivery could be suboptimal since skilled delivery was not associated with under-five mortality in the current study. Also, coverage of exclusive breastfeeding, an important an effective intervention on neonatal mortality is on the decline in Ghana (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Lastly, coverage level of early initiation of breastfeeding, a neonatal level intervention, and one of the two interventions that showed effectiveness at reducing under-five mortality in this study has been consistently low (Ghana

Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Addressing the increased odds of death with younger children will require improved access to quality skilled delivery. Clean postnatal care and early initiation of breastfeeding showed effectiveness at reducing mortality and since they are neonatal level interventions, increase in their coverage levels would be beneficial.

The higher odds of death of neonates is consistent with global trends. There are reports of increasing proportions of neonatal deaths (Keats et al., 2017; Liu et al., 2016; United Nations, 2015), and a slower decline in neonatal mortality than under-five mortality (Abir et al., 2015; Afnan-Holmes et al., 2015; Kanyuka et al., 2016; Kayode et al., 2014; Liu et al., 2016). The proportion of neonatal deaths increased from 39.3% in 2000 to 45.1% in 2015 at the global level (Liu et al., 2016).

Apart from neonatal deaths, being a multiple birth was positively correlated with under-five mortality, a 5 times higher odds of mortality from the logistic regression analysis. Multiple births are more likely to be complicated and may also require more skilled personnel who are not usually available. This could therefore, affect the survival of multiple births. After delivery, there is competition for breast milk and maternal attention among other things. Since multiple births are largely unavoidable, appropriate care during pregnancy and delivery, and social support from family, friends and the society at large could reduce the risk of deaths of multiple births. Similar results to this have also been documented. Abir et al. (2015) in Bangladesh, Shifa et al. (2018) in Ethiopia and Welaga et al. (2013) in northern Ghana found multiple birth to be associated with increased risk of under-five mortality.

Apart from these child level factors (being a neonate and multiple birth), that were associated with under-five mortality, children from mothers in polygamous marriages had twice higher odds of death. Rivalry among wives has been attributed to the higher odds of death. Limited resources and overcrowding have also been cited as reasons for the positive correlation of polygamy and child mortality (Arthi & Fenske, 2018). This finding is consistent with results reported in other studies (Kanmiki et al., 2014; Omariba & Boyle, 2007).

On socio-economic factors with protective effect on under-five mortality, children in households with three or more children under-five years were 81% less likely to die compared to those in households with one or two children under five years. Also, children of mothers with NHIS coverage were also 80% less likely to die. Having more children under-five years to take care of, could mean the mother will have more experience with taking care of children including identifying signs and symptoms of diseases. Having more children under-five in a household has been associated with early care seeking in Niger (Page et al., 2011). Children in households with higher number of members also had reduced odds of neonatal and under-five mortality in Ghana (Dwomoh et al., 2019).

Health insurance membership offers financial access to healthcare and is associated with increased and timely healthcare seeking (Blanchet et al., 2012; Bosomprah et al., 2015; Krumkamp et al., 2013). It could therefore, increase the use of all the healthcare associated interventions, and therefore its association with an 80% reduction in the odds of U5M. Similar results of the protective effect of NHIS on mortality has been reported (Dwomoh et al., 2019).

5.2 Socio-Demographic Factors not Associated with Under-Five Mortality Between 2003 and 2014

Among the individual level factors assessed for association with under-five mortality, skilled delivery, area of residence and wealth were not associated with mortality at the individual level. Socio-demographic factors, including area of residence and wealth either facilitate or hinder access to health care services which intern influence mortality. Therefore, if health care interventions have no impact on mortality, then factors that determine use of health care interventions will also likely not influence mortality. Also, with the increase in access to care through the Community base Health Planning Services (CHPS), several barriers to care for rural dwellers are likely to have been reduced in Ghana. Coverage levels of some interventions are also higher in rural areas than in urban settings. From the 2016 Malaria Indicator Survey (MIS), while urban dwellers have household long lasting insecticide treated net (LLIN) coverage of 65%, that of rural dwellers was 82% (Ghana Statistical Service, 2016).

5.3 Interventions and Risk Factors with Effect on Under-Five Mortality

Despite efforts at reducing U5M, mortality decline in Ghana is slow. The results showed that the various child health interventions impact child mortality differently, and this should be taken into account in child survival programme planning.

5.4 Effect of interventions on Under-Five Mortality at the individual Level

At the individual level, early initiation of breastfeeding, clean postnatal care and hygienic disposal of stool had effect on reducing under-five mortality, while IPTp showed decreased child survival.

5.5 Early Initiation of Breastfeeding

Proper maternal and child nutrition play a crucial role in child survival. They reduce the risk of major causes of deaths such as malaria, diarrhoea and pneumonia (Afnan-Holmes et al., 2015; Boerma, 2018; United Nations, 2015) and risk factors of death such as preterm, small for gestational age, stunting and wasting (Ghana Statistical Service (GSS) et al., 2015; Lawn et al., 2010). Breastfeeding has been shown to reduce the risk of infections and consequently, death of children under-five years (Abdullah et al., 2016; Edmond et al., 2006; Nambuusi et al., 2019; Raihana et al., 2019; Shifa et al., 2018). Early breastfeeding has additional benefits as it promotes warmth and bonding between infants and their mothers.

In this study, early initiation of breastfeeding caused a 66% reduction in the odds of death. Similar results of the association between early initiation of breastfeeding and under-five mortality have been documented (Abdullah et al., 2016; Clemens et al., 1999; Edmond et al., 2006; Nambuusi et al., 2019; Raihana et al., 2019). According to the GDHS, coverage level of early initiation of breastfeeding was 25.5% in 1998, 46.3% in 2003, 52.3% in 2008 and 55.6% in 2014 (Ghana Statistical Service et al., 2004; Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). This trend of coverage increase is slow. Considering the 2014 coverage level of the intervention, it has the potential to further reduce mortality if its coverage level is increased. Since this intervention does not require much logistics or expenditure to implement compared to interventions like skilled delivery, it should be prioritized.

5.6 Clean Postnatal Care

Children who had clean postnatal care had a 59% reduced odds of death. Clean postnatal care is defined as neonates receiving a preventive postnatal visit within 48 hours of birth (Ghana Statistical Service (GSS) et al., 2015). The assumption is that, neonates who receive clean postnatal care will subsequently receive adequate clean postnatal care in the home (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). Clean postnatal care is one of the interventions with the lowest coverage levels in Ghana. Coverage in 2008 was .6.5%, while that in 2014 was 22.8%. Its low coverage is therefore, an avenue to further reduce deaths if its coverage level is increased. Increase in the coverage level of clean postnatal care will affect major causes of death of neonates such as sepsis and diarrhoea. Result of the protective effect of clean postnatal care on mortality in this study is similar to that documented by some authors (Issaka et al., 2016; Kayode et al., 2014; Millogo et al., 2019; Shifa et al., 2018) but different from that reported by Akter et al. (2017) in Bangladesh.

5.7 Hygienic Disposal of Stool

Hygienic disposal of stool was associated with reduced odds of death from the assessment of factors associated with under-five mortality and from the survival analysis. Incidence rate of death was reduced by 60% among children under-five with hygienic disposal of stool from the Poisson regression. Stool is considered hygienically disposed of, if the child defecates into a toilet or the stool is put in to a toilet or latrine or the stool is buried. Children less than six months old are more likely to be defecating into diapers (from general observation, use of diapers has increased over the years), cloths and other materials. They are also more likely to be having exclusive breastfeeding and therefore, have limited contact with their surrounding environment. Therefore, the risk of contamination from food and the environment will be limited. Infection from stool will be more likely to occur through direct contact with those who handle the child, especially during feeding. Handwashing, especially after cleaning the child when the child defecates and before breastfeeding should therefore, be important in reducing the risk of infections. In Ethiopia, Azage and Haile (2015) found better stool disposal practices among caregivers of children older than 12 months compared to caregivers of younger children.

Coverage level of hygienic disposal of stool declined from 47.6% in 2008 to 39.9% in 2014. The Eastern (61.3%) and Western (54.5%) regions had the highest coverage levels of this intervention, while the Northern (9.6%) and Upper West (19.5%) regions had the lowest coverage levels. The low coverage levels means that their coverage levels could be scale-up for greater impact on under-five mortality reduction, especially in regions of Ghana with low coverage levels.

5.8 Intermittent Preventive Treatment of Malaria in Pregnancy with Sulphadoxine-Pyremethamine

However, at the individual level, intermittent preventive treatment of malaria in pregnancy with sulphadoxine-pyremethamine, a malaria control intervention, was associated with a 3 times higher odds of death. This intervention is an important determinant of neonatal mortality and its positive correlation with U5M is unfortunate. No studies have been found documenting its harmful causal effect on child survival. Contrary results of a protective effect on U5M has been documented in Uganda (Nambuusi et al., 2019). Coverage level was 45.5% in 2008 and 67.5% in 2014 according to the GDHS (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). A possible explanations of the unexpected result is error due to recall bias, since some participants received as many as twenty-four (24) doses of SP. The recommended dose by the Ministry of Health/National Malaria Control Programme during the period of the evaluation was at least two doses (Ghana Statistical Service (GSS) et al., 2015).

5.9 Effect of Interventions and Risk Factors on Under-Five Mortality at the Population Level

At the population level, reduction in the prevalence of wasting and stunting, increase in malaria control interventions, vaccines and labour and delivery management interventions (skilled delivery) contributed to mortality reduction, while breastfeeding and complementary feeding were responsible for excess mortality between 2008 and 2014 among children under-five years in Ghana.

5.10 Reduction in the Prevalence of Stunting and Wasting

Prevalence of wasting reduced from 8.5% to 4.7% between 2008 and 2014 and saved the most lives (11,918). This translated into a 19% reduction in under-five mortality rate. Reduction in the prevalence of stunting from 27.5% to 18.8% also made a substantial reduction in mortality (5,761 lives save, 11% mortality reduction). Taken together, stunting and wasting saved the most lives. A decline in stunting and wasting was achieved despite reduction in the prevalence of exclusive breastfeeding and complementary feeding during the period of the evaluation. In 2008, exclusive breastfeeding among children less than one month was 84.3%, but this reduced to 65.6% in 2014. Also, among children 1-5 months, prevalence of exclusive breastfeeding was 60.6% in 2008 and this reduced to 54.3% in 2014. This decline in exclusive breastfeeding contributed to a 4% excess death (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

Complementary feeding among children 6 months to 59 months also declined from 47.3% to 28.1% between 2008 and 2014 resulting in a 1% excess deaths at the population level (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). The decrease in prevalence of exclusive breastfeeding and complementary feeding is a cause for worry considering the importance of proper nutrition on child survival. Considering the decline in the prevalence of exclusive breastfeeding, children are not likely to be benefiting from its impact on stunting and wasting reduction.

Stunting and wasting greatly impact child morbidity and mortality. Several factors affect stunting and wasting including conditions like diarrhoea and mal-nutrition. Stunting, diarrhoea and fever were major conditions affecting child health in Ghana in 2008 and 2014. Stunting was the highest condition in 2008 and 2014. Compared to the national figure of 18.8%, stunting in the Northern region in 2014 could be considered very high (33.1%). An even greater concern is that, despite the already high prevalence of stunting in the Northern region, it was the only region that experienced an increased (0.7%) in stunting prevalence between 2008 and 2014. Upper East region recorded the highest stunting prevalence of 36% in 2008, but this reduced to 14.4% in 2014. Upper West region had the highest decline in wasting from 13.9% in 2008 to 4.4% in 2014. This could partly explain the higher under-five mortality in the Northern region compared to that in the Upper East and Upper West regions, although they are all among the poorest regions of Ghana. Addressing stunting, especially in the Northern region, should therefore be a top priority of the Ministry of Health, Ghana Health Service and other partners in the child survival business.

Health-facility based interventions addressing stunting and wasting might be limited. This is because severely stunted or wasted children are usually taken care of at facilities with the larger but less severely malnourished children not identified and treated. The food fortification programme with vitamin A, vitamin A supplementation for children (coverage increased from 55.6% in 2008 to 65.2% in 2014), Livelihood Empowerment Against Poverty (LEAP) programme introduced in 2007, and the School Feeding Programme introduced in the 2005-2006 academic year (Quaye et al., 2010), could be partly responsible for the decline in stunting and wasting.

It implies that further mortality decline can be achieved if complementary feeding and breastfeeding levels are increased. Managers of the School Feeding Programme should therefore, ensure that balanced diets are served. Coverage of vitamin A supplement for children should also be increased as coverage increased to 90% will save 242 lives. Similar results of the contribution of reduction in stunting and wasting to mortality decline have been reported (Afnan-Holmes et al., 2015; Amouzou et al., 2012; Doherty et al., 2016; Ruducha et al., 2017).

Additionally, similar results of the reduction in stunting and wasting, despite reduction in exclusive breastfeeding, have been documented in Ethiopia by Doherty et al. (2016). While decrease in breastfeeding resulted in 2300 additional deaths, between 2005 and 2011, a decline in stunting prevalence saved 8,400 lives and caused a 13% mortality reduction. Wasting prevalence also declined, saving 11,400 lives and an 11% reduction in mortality rate (Doherty et al., 2016). In Tanzania, however, improvement in breastfeeding and complementary feeding saved 2,400 lives of neonates and children (Afnan-Holmes et al., 2015). Also in Niger, improvement in nutrition contributed to a 19% reduction in under-five mortality, while vitamin A supplementation contributed to an 11% reduction in under-five mortality between 1998 and 2009, according to Amouzou et al. (2012). Additionally, in Malawi, reduction in wasting and stunting contributed to an 11% and 9% mortality reduction respectively between 2000 and 2013 (Kanyuka et al., 2016). Also in Ethiopia, Doherty et al. (2016) reported that 60,700 child deaths averted between 2000 and 2011 was as a result of reduction in wasting rates (18%) and stunting rates (13%). Ruducha et al. (2017) in Ethiopia documented that a 50% of 469, 000 lives saved between 2000 and 2011 was attributed to improvement in nutritional status of children under-five years old. From the forgoing, many countries benefited in mortality reduction from reduction in the prevalence of stunting and wasting. This means that strategies to further reduce the prevalence of stunting and wasting would be beneficial in sub-Saharan Africa (SSA) including in Ghana.

5.11 Malaria Control Interventions

Taken together, malaria control interventions (ITN/IRS and ACTs) made the most impact on mortality reduction at the population level. An increase in ITN/IRS coverage from 45.4% to 72.7% between 2008 and 2014 saved 8,524 lives resulting in a 16% point mortality reduction. Artemisinin-based combination therapy coverage level also increased from 11.3% to 26.2%, saved 5,702 lives and contributed to a 10% point mortality reduction. Malaria remains a top cause of under-five deaths in Ghana, and therefore, effective interventions targeting malaria deaths should have high impact. While household ITN/IRS made a significant impact (16% mortality reduction), they still have the potential for increased impact if their coverage levels are scaled up to 90%. Similar results of the impact of bed net on mortality have been documented (Afnan-Holmes et al., 2015; Amouzou et al., 2012; Kanyuka et al., 2016; Nakamura et al., 2011). Nakamura et al. (2011) in 2011 documented a 29% reduction in risk of mortality among children under-five years who use bed nets. In Malawi, a 5% to 80% increase in bed net coverage contributed to a 20% reduction in under-five mortality between 2000 and 2013 (Kanyuka et al., 2016). In Niger, introduction of bed nets contributed to a 25% mortality reduction between 1998 and 2009 (Amouzou et al., 2012). In Tanzania, bed net use saved 8000 lives (24% of mortality reduction) among children 1-59 months between 1990 and 2014 (Afnan-Holmes et al., 2015). However in Ethiopia, while bed net use caused only a 3% decline in mortality between 2000 and 2011, reduction in stunting and wasting and improvement in water and sanitation interventions contributed the most to mortality reduction (Doherty et al., 2016). Also in Uganda, indoor residual spraying was shown to reduce U5M (Nambuusi et al., 2019).

Comparing ACTs to ITN/IRS, ACTs also saved a substantial number of lives (10% reduction in mortality rate), but this was lower compared to that achieved by ITN/IRS (16% reduction in mortality rate). This is likely due to its low coverage change (11.3% to 26.6%) between 2008 and 2014 compared to that of ITN/IRS (45.4% to 72.7%). The low coverage level of ACTs could be a combination of delay in treatment and none treatment.

According to Ferrer et al. (2016), while 93.1% and 92.8% caregivers in the Volta and Northern regions of Ghana respectively sought care for children under-five years for treatment of malaria, only 38.1% and 59.5% respectively did so within 24 hours of the onset of illness. This shows a significant delay in the timeliness of treatment. Similarly, from the 2016 Malaria Indicator Survey (MIS), while 72% of children with fever sought care, only 48% did so within 24 hours (Ghana Statistical Service, 2016). These delays in treatment are at variance with the national target of a 90% treatment of malaria within 24 hours (Ghana Statistical Service, 2016). The delay could explain the continuously large contribution of malaria to under-five mortality and the generally low mortality decline in Ghana. Malaria is a top cause of morbidity and mortality of children under-five years and uncomplicated malaria can progress rapidly to severe disease with delay in treatment.

Artemisinin-based combination therapy also has the potential to save additional lives since its current coverage level is low in the country. It should therefore, be one of the interventions to focus on to further reduce mortality, especially in malaria high burden regions. Artemisinin-based combination therapy coverage level increased from 9.6% in 2008 to 22.6% in 2014 in the Upper West region. Fever prevalence decreased by 6.1% nationally between 2008 and 2014, but fever increased by 4.6% in the Upper West region. Also, from the 2016 MIS, fever prevalence increased between 2014 (13.8%) and 2016 (30%). Although malaria preventive interventions have shown to be very impactful, malaria prevalence is still high and on the ascendency. This makes accurate and timely treatment still crucial.

Compared to the treatment of malaria, treatment for diarrhoea and care-seeking for pneumonia made little impact on mortality although they are important contributors to under-five mortality. Oral rehydration salt (ORS) coverage increased from 44.5% to 48.7% and resulted in 1,038 lives saved and contributed to a 2% decrease in mortality rate. The implication is that diarrhoea as a cause of death might increase in the future if coverage of interventions targeting diarrhoea are not scaled up. Rota virus vaccine might not save additional lives if its coverage level is maintained or even increased. Coverage of treatments for diarrhoea and water and sanitation services need improvement to further reduce diarrhoeal mortality in Ghana. Care-seeking for pneumonia also increased from 50.7% to 52.6% and saved 485 lives resulting in a 1% decrease in mortality rate. The low increase in care seeking for pneumonia could be because mothers of caregivers of children might not consider pneumonia severe enough to warrant care seeking at health facilities (Webair & Bin-Gouth, 2013).

In Malawi, treatment of malaria, diarrhoea and pneumonia collectively contributed to a 23% reduction in mortality according to Kanyuka et al. (2016). In Ethiopia however, while ACTs caused only a 2% decline in under-five mortality, care-seeking of pneumonia contributed to a 9% mortality reduction, and ORS, a 11% reduction in mortality between 1990 and 2014 (Doherty et al., 2016).

5.12 Vaccines

Vaccines, have historically, and in recent times, contributed significantly to mortality reduction (Afnan-Holmes et al., 2015; Doherty et al., 2016; Kanyuka et al., 2016; United Nations, 2015). At the population level, pneumococcal and rota virus vaccines were the vaccines that made the most impact. Pneumococcal vaccine saved 2,406 lives

(8% mortality reduction), while rota virus vaccine saved 1,033 lives (3% mortality reduction). These vaccines were introduced in 2012 (did not exist in Ghana in 2008) and therefore, their coverage change between 2008 and 2014 was high, 84.2% for pneumococcal vaccines and 87.6% for rota virus vaccines. The high change in coverage meant that the two vaccines had a lot of deaths to prevent and thus, their high impact. Coverage levels of pneumococcal and rota virus vaccines were comparable with the other vaccines in 2014. These were DPT, (88.5%), *Haemophilus Influenza* type B (HiB) (88.5%) and measles (89.3%) (Ghana Statistical Service (GSS) et al., 2015)..

Nonetheless, pneumococcal and rota virus vaccines are not likely to save more lives than their current impact in the future just like the older vaccines. This is because, with a national level coverage of over 80% for most vaccines, any further increase in coverage will be less than 20%. Also, if the high coverage levels reduce the prevalence of vaccine preventable diseases in the population like diphtheria and tetanus, they will likely not contribute significantly to mortality decline even if their coverage levels are further increased. This means that these vaccines with high coverage levels together with the effect of herd immunity, will likely not contribute significantly to mortality decline even if their coverage levels were further increased, except if the prevalence of vaccine preventable diseases increase. This is because as coverage levels of vaccines increase, prevalence of diseases decrease and transmission of the vaccine preventability also decrease, and therefore, intervention will have fewer deaths from the diseases to prevent. Furthermore, tetanus toxoid vaccine which is also targeted at reducing neonatal mortality did not show impact on mortality in this study. This implies that at most, mortality rate will remain constant at this high levels of vaccine coverage, but any reduction in these coverage levels will cause increase in mortality. Unfortunately, some vaccines have been found to be associated with increased chances of death (Aaby et al., 2018; Aaby, Ravn, & Benn, 2016; Klein et al., 2016; Welaga et al., 2012).

Considering that one of the most effective tools for reducing mortality does not have much potential in further mortality reduction, coverage of other high impact interventions, especially those with low coverage levels need to be increased and new interventions introduced to achieve rapid mortality decline. Small-scale use of chlorine in water has been proposed (Herrick et al., 2017), but improvement of water connection into homes and yards will provide a more effective and lasting solution. The recently introduced malaria vaccine (Government of Ghana, 2019), might also cause a significant decline in mortality if its effectiveness is high. Notwithstanding, it has been documented to be associated with increased death, especially among girls (Klein et al., 2016).

According to Boerma (2018), vaccines are among the interventions with high coverage levels in Western and Central Africa where rates are above 80%. In Ghana, vaccine coverages were above 80% in all regions and nationally, except in the Northern region where DPT was 75.1% in 2008. In 2014, coverages were again over 80% except for pneumococcal vaccine which was about 78% in the Upper East region. Measles vaccine was 79% in the Upper East region, while pneumococcal vaccine was 77% in the Northern region in 2014 (Ghana Statistical Service (GSS) et al., 2015).

Results from this study are similar to that documented in Malawi. Vaccines contributed to a 17% mortality reduction between 2000 and 2013 in Malawi according to Kanyuka et al. (2016). In this study, changes in coverage level of interventions were neonatal tetanus protection (57% to 62%), DPT3 (84% to 93%), measles (83% to 92%), Hib, (30% to 93%) and pneumococcal (0% to 97%). In Tanzania, Hib vaccine contributed to a 27% mortality reduction saving 9,100 lives among children 1-59 months because of increase in its coverage level (Afnan-Holmes et al., 2015). In Ethiopia however, contrary results were documented with measles vaccine contributing to only 8%, Hib vaccine 10% and tetanus vaccines 6% of reduction in mortality (Doherty et al., 2016). In this study, reduction in the prevalence of wasting (18%), stunting (13%) and water, sanitation and hygiene interventions (13%) rather contributed the most to mortality reduction.

5.13 Skilled Delivery

In this study, skilled care through labour and delivery management contributed significantly to lives saved (4,726 lives saved, 8% reduction in mortality rate). Skilled delivery is one of the main strategies targeted at reducing neonatal mortality which is a significant contributor to U5M. Increased skilled delivery could improve the coverage and quality of clean postnatal care and early initiation of breastfeeding, which are effective at reducing under-five mortality. In Tanzania, among neonates, skilled delivery and emergency obstetric care contributed to a 29% (6,200 lives saved) reduction in mortality between 2008 and 2014 (Afnan-Holmes et al., 2015). However, Ethiopia achieved the MDG4 on child survival with coverage of skilled delivery between 2000 and 2011 with less than 5% coverage of skilled delivery. This contributed to a 3% decline in U5M (Doherty et al., 2016).

Unfortunately, skilled delivery was not associated with mortality reduction in this study. This lack of association could be due to low effectiveness of the interventions as a consequence of poor quality (Manu et al., 2014; Nesbitt et al., 2013). A study by Lambon-Quayefio and Owoo (2014) in Ghana also found no association between skilled delivery and neonatal mortality. In Ghana, skilled delivery coverage level increased from 58.7% in 2008 to 73.3% nationally in 2014, but it still did not have any impact on mortality reduction (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). In the Brong Ahafo Region of Ghana, while coverage of health facility care was 68%, high quality health facility care was 18% (Nesbitt et al., 2013).

In Ghana, while coverage level of skilled delivery was 84.3% in 2008 and 92.1% in 2014 in the Greater Accra region, neonatal mortality increased from 21 to 25 deaths per 1,000 live birth during the same period. This could mean that skilled delivery, one of the key interventions with the potential to reduce neonatal mortality is not producing the desired effect. A similar observation can be made from the Ashanti region. In the Ashanti region, coverage of skilled delivery was 72.6% in 2008 and this increased to 86.3% in 2014, yet, the region recorded an increase in neonatal mortality from 35 to 42 deaths per 1,000 live birth from 2008 to 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

However, in the Upper West region where the coverage level of skilled delivery was lower than that in the Greater Accra and Ashanti regions, 46.1% in 2008 and 63.7% in 2014, neonatal mortality decreased from 45 to 37 deaths 1,000 live births between the periods. This is similar to that in the Northern region, where coverage of skilled delivery was 27.2% in 2008 and 36.4% in 2014, but achieved a neonatal mortality declined from 35 to 24 deaths 1,000 live births within the period (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). This means that high coverage of skilled care will not necessarily lead to rapid mortality reduction. According to Kruk et al. (2018) neonatal mortality ranked second in deaths due to poor quality of care in low and middle income countries.

The lack of effect of skilled delivery on under-five mortality at the individual level could also be because women with pregnancies that have complications will likely visit health facilities or be referred to health facilities for more professional care. Also, caesarean section (C/S) is suggested for pregnancies with complications and therefore, since complicated pregnancies are more likely to result in child deaths than normal pregnancies, it could explain the ineffectiveness of skilled delivery in mortality reduction in this study. For example, multiple births are more likely to be complicated and thus be delivered by skilled personnel. In this study, multiple births had a strong association with mortality. However, Abir et al. (2015) in Bangladesh and Titaley et al. (2011) in Indonesia, found lower odds of deaths of children whose pregnancies were complicated compared with those without complications. This observation is also plausible if complicated pregnancies are given more attention and pregnancy related complications identified and managed to limit the chances of adverse pregnancy outcomes.

Lastly, caesarean deliveries are done only by skilled personnel. However, caesarean delivered children stay longer at the health facility compared to children born by normal delivery. Therefore, if the quality of care at health facilities is poor, children delivered by C/S will have higher odds of death, especially from infections as infections are a major cause of neonatal and under-five mortality. On the contrary, all C/S delivered children will likely have clean postnatal care which is protective against neonatal mortality. Higher odds of death of children delivered by C/S has been documented by Ezeh et al. (2015) in Nigeria, but Titaley et al. (2011) in Indonesia, found no association between delivery type and early neonatal mortality.

5.14 Other Water and Sanitation Related Interventions

The impact of water and sanitation related interventions on mortality reduction at the population level was low compared to that obtained from other studies. In Ghana, while prevalence of time to improved water source within 30 minutes increased from 61.9% to 69.9%, improved sanitation coverage increased from 11.2% to 13.6%. And, these together saved 153 lives and contributed to zero mortality reduction. Water connection in the home declined from 14.2% to 9.7% and resulted in 661 additional deaths and contributed to a 1% mortality increase in 2014 relative to 2008. These coverage levels can be considered very low compared to coverage levels in Malawi where the MDG4 was achieved. In Malawi, coverage level of improved water increased from 67% to 87%, while that of improved sanitation also increased from 83% to 95% between 2000 and 2013 (Kanyuka et al., 2016). In Ethiopia, Doherty et al. (2016) reported 13% of mortality reduction being due to improvement in water, sanitation and hygiene interventions.

It can therefore, be argued that beyond health system interventions, strategies to improve access to water and sanitation facilities will be useful in reducing under-five mortality. Advocacy for the improvement in the coverage of water and sanitation interventions as a means of reducing under-five mortality should be promoted by the Government of Ghana/Ministry through the Ghana Health Service and other organizations working in the field of child health. This is because water and sanitation factors influence major causes of under-five deaths such as sepsis, diarrhoea and pneumonia. In addition, because the coverage levels of these sanitation and hygiene related interventions are relatively low currently, they have much potential to further reduce mortality if their coverage levels are increased.

It can be observed that although interventions are similar across the countries, slightly different interventions contributed the most to mortality reduction in the different countries. Just as other countries might be exploring ways to improve on interventions that did not contribute much to mortality reduction previously, Ghana will have to do same. Water, sanitation and hygiene related interventions contributed significantly to mortality reduction in Ethiopia but not in Ghana. This should therefore be an area to explore as a measure to address under-five mortality.

5.15 Trajectory of Under-Five Mortality in Ghana

Under the current package of interventions targeted at reducing under-five mortality, rapid decline in mortality is unlikely, at best, mortality rate will be stagnant. From the individual level impact evaluation, only two (2) out of the eight (8) interventions had causal effect on mortality reduction. Also from the population level impact evaluation, even at universal coverage, rapid mortality decline will not be guaranteed.

Historically, vaccines have contributed greatly to mortality reduction, but future potential on mortality decline is unlikely due to the current high coverage levels. It can also be argued that considering the current major causes of death of children within the neonatal period, high coverage of quality skilled care is necessary. Unfortunately, skilled delivery did not affect under-five mortality in Ghana during the period of the evaluation. It might therefore, under the current situation, not contribute to mortality reduction. Poor quality of skilled care could compromise the effectiveness of interventions such as early initiation of breastfeeding and clean postnatal care, the only two interventions that showed effectiveness at reducing under-five mortality at the individual level.

Although achieving 100% of all the above interventions will be a daunting task, Ghana might still not reach the SDG target of at least neonatal mortality rate of 12/1000 live births and under-five mortality rate of 25/1000 live births. This means that the current package of intervention targeting child mortality in Ghana might not deliver the needed decline in mortality and possibly achieve the SDGs. Some authors have criticised the MDGs and SDGs as being unfair to Africa (Lange & Klasen, 2017) as most African countries will require a faster decline in mortality during the SDGs period than that achieved during the MDGs period (Boerma, 2018). However, the global drive might spur Ghana on to achieve significant decline in mortality even if it will not meet the target as happened during the MDGs period (Golding et al., 2017; United Nations, 2015).

Unfortunately, McArthur et al. (2018) have predicted a slower decline in mortality in places with previously high decline. Ceiling effect due to the already high coverage levels of some interventions, and adverse effect of interventions could account for this. The consequence of this could be stagnation and possible increase in under-five mortality in future. In Ghana, the Greater Accra, Upper East and Ashanti regions had good coverage of DPT, HiB and measles of over 90% in 2014. In addition, coverage level of skilled delivery was over 90% in the Greater Accra region and over 80% in the Ashanti regions in 2014, yet the Greater Accra and Ashanti regions achieved the slowest decline in mortality between 2008 and 2014 (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009).

Additionally, Greater Accra region had the lowest prevalence of diseases and risk factors of under-five morbidity and mortality in the country. The Ashanti region also experienced decline in all major diseases and risk factors from 2008 to 2014, and yet these two regions it did not experience significant mortality decline between 2008 and 2014 (Ghana Statistical Service (GSS) et al., 2009). Greater Accra had its mortality rate decline from 50/1,000 live births to 47/1,000 live births, while the Ashanti had no change in mortality rate 80/1,000 live births in 2008 and 2014. In contrast, mortality rate declined in the Upper Northern region from 137/1,000 live births to 111/1,000 live births and in the Upper West region, from 142/1,000 live births to 92/1,000 live births during the same period, although coverage of interventions were lower and prevalence of diseases and risk factors higher in these regions.

Also, the Upper West region had under-five mortality rate (155.3/1000 live births) similar to that of the Upper East (155.6/1000 live birth) and Northern (171.3/1000 live births) regions in 1998 before the Community-based Health Planning Services (CHPS) programme in the Upper East region which caused a huge mortality decline from 155.6/1000 live births in 1998 to 79/1000 live births in 2003 in the Upper East region (Awoonor-Williams et al., 2010). The Upper West region also had a huge decline in U5M from 208/1000 live births in 2003 to 142/1000 live births in 2008 and 92/1000 live births in 2014. However, mortality decline especially in the Upper East region has been minimal after the period of high decline. Neonatal mortality increased from 17/1000 live births in 2008 to 24/1000 live births in 2014 in the Upper East region (Ghana Statistical Service (GSS) et al., 2015; Ghana Statistical Service (GSS) et al., 2009). It can therefore be observed that regions of Ghana with high mortality rates historically, experienced higher decline in mortality rates than those with previously lower rates. This phenomenon was observed in the MDGs period at the global level. Countries with previously higher mortality rates experienced the most absolute reduction in mortality accounting for the highest absolute reduction to mortality in SSA (United Nations, 2015).

It therefore suggests that, rapid mortality decline will only be possible if there is increase in coverage of the few high impact interventions (early initiation of breastfeeding, clean postnatal care, hygienic disposal of stool, treatment of malaria with ACTs within 48 hours and ITN/IRS), especially those with low coverage level. In addition, improvement in the quality of interventions, exploring avenues to reduce stunting and wasting and introduction of new interventions might yield accelerated mortality decline. The new interventions should focus on reducing neonatal mortality since it is on the increase in Ghana as at the global level. If such measures are not taken, Ghana might experience increase in under-five mortality rate as forecasted to happen in the African continent (Golding et al., 2017; United Nations, 2015).

5.16 Limitations of Study

5.16.1 Methodological Limitations

Coarsened exact matching (CEM) like other matching methods applied to observational data, matches on observed potential confounders and therefore, there might still be residual confounding due to unobserved confounders. However, the confounders adjusted for comprised all confounders identified in the literature review and therefore, the effect of unobserved confounders is negligible. Lives save tool (LiST) assumes a constant effectiveness of intervention which might not hold in situations where the quality of the intervention being delivered is poor. However, the combination of methods allowed for judgement on the effect of this limitation of LiST on the study results.

5.16.2 Data Limitations

At the population level, not all interventions are included in LiST. For example, seasonal malaria chemoprevention (SMC) is not included in the LiST. However, the most important interventions are included. For the individual level analysis, there was no information on the vaccination, stunting, wasting, morbidity status and treatment seeking of children who died. The impact of these could therefore, not be estimated at the individual level, but this was estimated at the population level.

Some variables were based on self-reporting and thus, subject to recall bias. Self-reported responses may also be prone to social desirability bias. The use of proxies, for example, the use of fever for malaria and thus, treatment with ACTs based on fever is not very appropriate since not all fever cases are malaria cases.

5.17 Strengths of the Study

Nationally and regionally representative data were used and therefore, the results are generalizable to all children under-five in Ghana. Response rates were also very high, over 90% which adds to the generalizability of the study findings. Triangulation of analysis using CEM, LiST, missed tool, regression and survival analysis are a strength of this study. The consistency of some results across methods adds to the validity of the study results. Most analysis explaining under-five mortality in the literature consider socio-demographic factors. Analysis in this study, took into account both socio-demographic and intervention factors since all these interplay in determining child mortality.

Results of studies using LiST are comparable globally since the Demographic and Health Survey (DHS) data collection methods and variables are similar across countries. This will enable comparison of progress of child survival in Ghana with that of other countries, and possibly learn from best practices from other countries.

5.18 Situating the Study in the Conceptual Framework

The findings of this study within the context of the conceptual framework can be situated within objective three (3) of this study which determines the contributions of the various interventions to mortality reduction. There is advocacy for increased use of, and coverage of interventions targeted at reducing morbidity and mortality. The theory of change underpinning this model is that increase in use of interventions will improve child survival. However, despite several (8) interventions evaluated, only two (2), early initiation of breastfeeding and clean postnatal care showed effectiveness at reducing the incidence of death. Based on this evidence, there is the need to revise the conceptual framework used for this study. The revision is necessary to inform future researchers to take into consideration, interventions with the greatest effect on under-five mortality. The revised framework is presented in Figure 9.

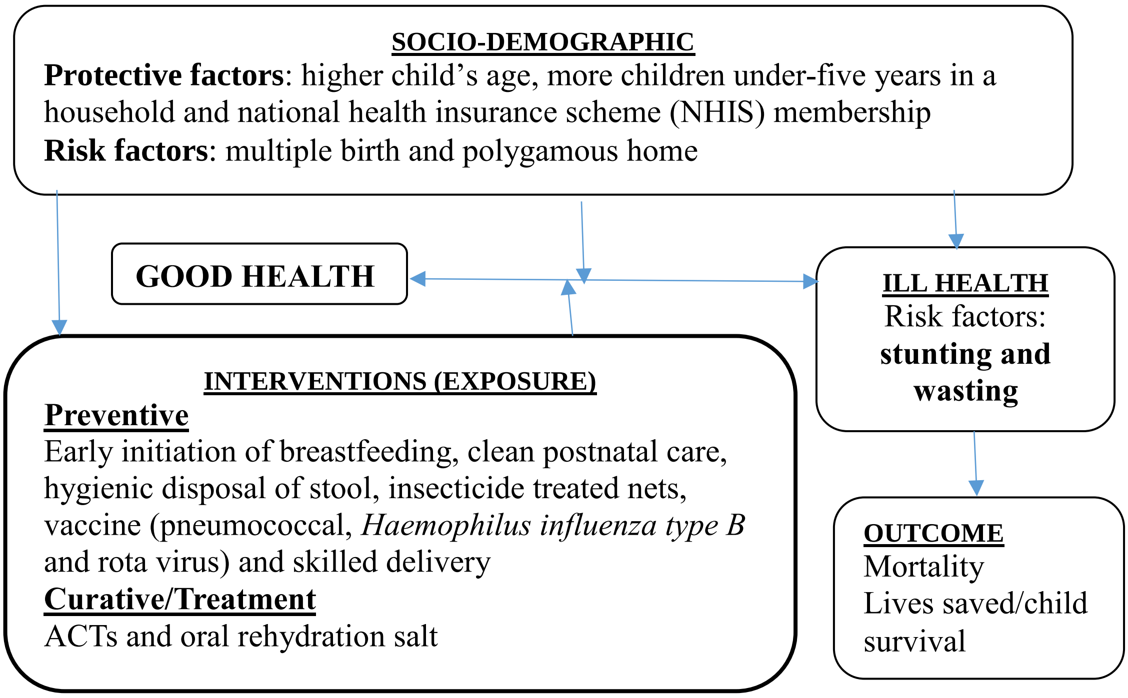

Figure 9: Revised conceptual framework on determinants and impact of interventions on child mortality

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Different interventions impact child mortality or survival to different extents in Ghana. This should be taken into account in child survival programme planning.

1. Of the eight (8) interventions assessed for effectiveness at reducing under-five mortality, two (2) interventions (early initiation of breastfeeding and clean postnatal care) showed effectiveness on mortality reduction. This therefore, suggests that the scope and content of the current package of interventions targeted at reducing U5M, will likely not achieve rapid decline in mortality. At best, the mortality rate will be stagnant.
2. Insecticide Treated Net/Indoor Residual Spraying (ITN/IRS), Artemisinin-based Combination Therapy (ACTs), pneumococcal vaccine, rota virus vaccine, skilled delivery and reduction in stunting and wasting made the greatest impact on mortality among children born between 2003 and 2014 at the population level in Ghana.
3. Labour and delivery management, ITN/IRS, ACT and water and sanitation interventions would have made the most impact had the 2014 coverage levels of interventions been scaled up to 90% in 2015.
4. In the midst of the various interventions, being a neonate, multiple birth or from a polygamous home put children at a higher risk of under-five mortality. Addressing issues affecting the health of children in polygamous homes and multiple births could be beneficial. In contrast, belonging to a home with more number of children under-five years and, a mothers with health insurance coverage reduced odds of death. Therefore, measures to improve on the services

of the National Health Insurance Scheme, including improving the availability of diagnostic and treatment logistics might contribute to improved child survival.

6.2 Recommendations

1. The Ghana Health Service (GHS) and other stakeholders in the field of child health, through community health nurses, should identify children at higher risk of death for close monitoring to identify danger signs for prompt attentions. These children should include neonates, multiple births, children from polygamous homes, and stunted and wasted children.
2. The GHS should also explore ways to increase coverage of interventions with low coverage levels and those with the potential to further reduce mortality. These should include breastfeeding, complementary feeding, skilled delivery, clean postnatal care, ACT, ORS and antibiotics for the treatment of pneumonia.
3. The GHS and its partners, should additionally, explore ways to reduce the prevalence of stunting and wasting. This could include liaising with the Ministry of Education to ensure that meals provided under the school feeding programme are balanced diets.
4. In relation to policy, the Government of Ghana should prioritize addressing water, sanitation and hygiene issues in line with the Sustainable Development Goal 6 (SDG6).

6.3 Contribution to Knowledge

1. The study demonstrated that interventions with the most impact on under-five mortality between 2003 and 2014 in Ghana at the individual level were early initiation of breastfeeding and clean postnatal care.
2. At the population level, ACTs, ITN/IRS, pneumococcal and rota virus vaccines and reduction in the prevalence of stunting and wasting made the most impact on mortality rate reduction.
3. The study results have provided a better understanding of the trend of mortality decline in Ghana. Under the current trend of increase in coverage levels of interventions, rapid mortality decline is unlikely.

6.4 Further Research

The results from this study demonstrates the need for further research work. These include:

1. The effect of intermittent preventive treatment of malaria in pregnancy with sulphadoxine pyremethamine (IPTp-Sp) on U5M needs further investigation.
2. The reasons for the reduction in prevalence of exclusive breastfeeding and complementary feeding should be explored.
3. Avenues to increase breastfeeding and complementary feeding and reduce stunting and wasting need to be investigated.
4. There is the need to assess the quality of skilled delivery since skilled delivery had no effect on mortality reduction.

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