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Water/Sanitation, Hygiene, and Risk Factors Associated With Under-5 Mortality in Côte D'Ivoire

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Abstract

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by

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MPH, Walden University, 2014

Diploma, Human Resources Management, Université de Côte D'Ivoire,1999

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Despite remarkable progress in children's survival since 1990, the global burden of the under-5 mortality rate (U5MR) remains immense. According to the World Health Organization, about 5.2 million children below 5 died in 2019, with 14,000 dying each day. Literature reveals that the lack and limitation of water, sanitation, and hygiene (WaSH) are linked to deaths in childhood. Cote d'Ivoire still lags behind expectations with 79 per 1000 live births in 2019 rather than 25 and below, so there is a need to uncover to what extent the U5MR is affected by WaSH. Through a cross-sectional design guided by the integrated behavioral model for water, sanitation, and hygiene and the health and human rights framework, this study examined the association between access to WaSH and U5MR using Cote d'Ivoire Demographic Health Surveys data sets: 2005-2020. Cox proportional hazards method was used to analyze the effect of WaSH variables on U5M. The results showed that the risk of U5MR is 22.4% higher among women with access to unimproved sanitation sources (HR:1.224, 95% CI: 1.044- 1.435). P=0.031compared with those with improved sanitation facilities. The risk of U5MR was 20.5% higher in women with unimproved water (HR:1.205, 95% CI: 1.000- 1.453). The risk of U5M among women was 77.3% (HR: 1.773,95% CI: 1.129- 2.784) higher in women with inadequate hygiene versus those with adequate hygiene. The likelihood of U5M is 49.1% higher (HR: 1.491 [95% CI: 1.021- 2.178] (p=0.039) among women from households with improved WaSH compared to counterparts with unimproved WaSH. Social change suggests educating and promoting access to improved WaSH to the targeted populations for preventive behaviors and minimizing the risk of U5MR.

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Dedication

I would like to dedicate this work to the affected populations, the experiences of affected mothers regarding the loss of their children under the age of 5 — *more particularly, among the* female strata of the population at reproductive age who have been *underrepresented in* the literature, and those disadvantaged populations who may be disproportionately affected in various instances e.g., gender, health, and SES.

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Chapter 1: Introduction to the Study

Globally, the mortality rate among children less than 5 years dropped to 39% from 50% per 1,000 live births (United Nations Inter-Agency Group for Child Mortality Estimation [UN IGME] & United Nations Maternal Mortality Estimation Inter-Agency Group [UN MMEIG], 2019). Despite substantial progress in child survival overall, huge disparities still appear between regions; for instance, in 2018, more than 82%, 8 in 10 of the global burden of mortality among children under 5, reside in Sub-Saharan Africa (SSA) (54%) and South Asia (28%) (UN IGME & UN MMEIG, 2019). As these figures indicated, globally, SSA and South Asia respectively account for the highest death rates among this age group. Between 60 and 125 of every 1,000 newborns have died before reaching 5 years of age in 28 nations, including: Afghanistan, Haiti, SSA countries, and Pakistan (United Nations, Department of Economic and Social Affairs, Population Division, 2019). Comparatively, in 2019, an Australian/New Zealand child under the age of 5 is 20 times more likely to survive than an SSA child (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Côte d'Ivoire, located in West Africa (SSA), was classified among the 79 nations with the highest under-5 mortality rate (U5MR) in 2016 and still lag behind expectation with 92 per 1000 live birth U5MR (The World Bank Group, 2018). Additionally, while the average 2019 U5MR for SSA was 76 per 1000 live births (The World Bank Group, 2021), Cote D'Ivoire still had a relatively higher U5MR of about 79 per 1000 live births in 2019 (The World Bank Group, 2021).

In exploring factors influencing death among children under 5, the literature has revealed that lack and limitation of water and proper sanitation, as well as subsequent contributing factors including lack of proper hygiene, were among predictors repeatedly linked to the high death/diseases rates in childhood, mainly in disadvantaged regions of Latin America, Africa, and Asia (Angoua et al., 2018; Darvesh et al., 2017; United Nations Development Program, 2019; The World Bank, 2019). While 1.1 billion individuals do not have access to potable water, 38 million reside in the Middle East, 49 million in Latin America, and 314 million in SSA. According to the United Nations Development Programme (2019), 700 million individuals live in water-stretched nations (i.e., Latin America, Middle East, and SSA) and are predicted to rise to 3 billion by 2025. This dramatic situation presents a critical threat and risk for the life of children who live in these regions, with children expected to face crucial vulnerabilities induced by lack or incapacity (Pink, 2013). The scarcity of clean water and basic sanitation services affects the lives of more than 40% of individuals globally (The United Nations Development Programme, 2019). In Côte D'Ivoire, more than eight million people (about 43% of its population) lack adequate sanitation facilities, and more than four million still use unsafe drinking water sources, particularly in rural areas (UNICEF Côte D'Ivoire, n. d.). Globally, about 5.6 million children less than 5 years old died in 2016 (World Health Organization (WHO, 2018). The lack of these substantial and vital elements exposed millions of children to illnesses associated with water, sanitation, and hygiene (WaSH) and subsequently leading to preventable death. Each day, more than 800 children die, and this mortality is attributed to preventable illnesses associated with poor WaSH (UNICEF,

2019b). In fact, many of these children die each day from diarrhea and other illnesses mainly led by lack and/or improper sanitation and water sources (UNICEF Côte D'Ivoire, n. d).

As aforementioned, the present research focused on children under 5 in Côte D'Ivoire, West Africa, with their burdens associated with limitations in basic needs including clean water, adequate sanitation, and hygiene. This study may lead to positive social changes with further understanding of the strength of association between WaSH and U5MR in Cote D'Ivoire by providing program planners, public health practitioners, and governmental agencies important insights for designing targeted strategies and programs to tackle the problem the priority population faces. Finally, such insights could inform decision making for further planning and to design effective upstream population-based strategies to alleviate the health burden of the local population in Côte D'Ivoire. In the next section, I provide the background for the study with a brief review of the literature in support of WaSH and other factors that may influence the health and mortality of children less than 5. I also incorporate the research questions, the problem statement, the conceptual framework, the definitions of terms, the purpose of the study, the nature of the study, significance, assumptions, scope and delimitations, and summary.

Background of the Study

Access to good WaSH conditions (i.e., toilets, potable water, and proper hygiene) is essential for child development, health, and survival (Adebowale et al., 2017; Alemu, 2017; Darvesh et al., 2017; Fink et al., 2011). As the WHO/UNICEF/World Bank group/United Nations (2015) asserted, child mortality is a key indicator used by many

countries around the world to evaluate the health and well-being of their children (Adebowale et al., 2017). The literature about WaSH and U5MR highlighted the magnitude of the problem, its significance, and the social determinants of the target population health (e.g., socio-economic, and social burden associated with high disparities based on geographic setting and socio-economic conditions). Globally, lack and limitation of water affect more than 40% of the population, an alarming figure that is expected to increase with the effect of global warming (United Nations Development Programme, 2019).This alarming public health problem induces a serious threat to the life of the local population, most particularly, children (United Nations, 2019). Previous studies have shown a correlation between clean water, adequate sanitation, child health, and survival (Alemu, 2017; Bohra et al., 2017; Cairncross et al., 2010; Pink, 2013; World Health Organization, n. d.). Each year, the inability to access water takes the lives of more children than the total mortality attributed to Malaria, Measles, and HIV/AIDS (Pink, 2013). From a human security perspective, sanitation, water, and child health have a critical linkage with child health. For instance, open sewage and inadequate sanitation facilities severely contaminate water supplies, leading to death and illnesses (Pink, 2013).

In further exploring what factors have led children under 5 to be more affected by premature death and associated diseases, the literature suggested that prominent attributable factors include limited resources, lack of clean water, appropriate hygiene, and sanitation as well as socio-economic and socio-demographic variables (Alemu, 2017; Angoua et al., 2018; Darvesh et al., 2017; Pink, 2013; United Nations Development Programme, 2019). Socioeconomic conditions, geographic areas, and socio-political

crises, for instance, affect the population through WaSH and related morbidity and mortality (Angoua et al., 2018). For example, the increasing urbanization rate, the recent civil war, and the rural exodus of the population in Abidjan have had a significant impact on the population's well-being and overall health. Particularly, the 2002 social crisis and subsequent rural exodus have increasingly led to the formation of informal and unplanned settlements. Most often, such informal places lack basic urban facilities (e.g., waste collection, water, and sanitation; Angoua et al., 2018). Additionally, the rural exodus is associated with extreme poverty of rural habitants; consequently, they often move from rural zones into urban zones for means of a better life. Conditions of life, access to water, sanitation, and infrastructures are bad in rural places compared to cities (WHO, UNICEF, 2014). With regards to the geographical factors (such as rural versus urban) and WaSH, in spite of remarkable progress, both uneven and steady, 96% of the global populations were using improved drinking water sources in 2015 versus 84% (urban and rural respectively), while 82% of the urban global populations were using improved sanitation facilities versus 51% in rural populations (urban and rural respectively; Darvesh et al., 2017). This situation affects the health of the exposed urban vulnerable population as exemplified in previous studies in Cote D'Ivoire by Angoua et al. (2018). In their study, the authors suggested that various flaws in the management of sanitation and water systems trigger the life and health of exposed local habitants to diseases linked to WaSH conditions e.g., diarrhea, malaria, typhoid, and fever. Despite great strides to mitigate the issue, reaching the expected targets still is slow. Angoua et al. suggested a further understanding of the economic, demographic, and social predictors to accessing

sanitation and water facilities in these places to alleviate this problem holistically and sustainably, hence minimizing risky conditions. Diarrhea is one of the main risk factors for deaths and illnesses among children below 5 (Darvesh et al., 2017). Despite all the progress to reduce diarrhea-related death, incident diarrhea and related mortality still varied and were found to be unequally distributed among regions and between SES (Darvesh et al., 2017).

Scaling up and promoting targeted interventions e.g., access to improved sanitation facilities, provision of safe water, and hygiene education could substantially decrease incident diarrhea in young children. Limitations in accessing clean water and sanitation affect incident diarrhea and related mortality in developing nations. In addition, diarrhea is one of the main causes of death among children below 5 (Clasen, et al., 2014; Darvesh et al., 2017). In the early twentieth century, childhood mortality was prioritized in the health debates. Policymakers and health professionals have prioritized childhood health outcomes to fight the increasing mortality in childhood (Adebowale et al., 2017). Not only has this interest been extended worldwide, but it has also led to craft strategies to halt the under-5 mortality by 2/3 between 1990 to 2015, based on the Millennium Development Goals (MDGs; Adebowale et al., 2017).

Following the above needs and urgency to address the issue, The Millennium Development Goal 4 (MDGs4), since its introduction, aims at reducing the U5MR by 2/3 from 1990 to 2015 (United Nations, 2015). According to the MDG 2012 report, while many regions worldwide were on track toward reaching the MDGs by the 2015 expected target, most SSA nations could not (United Nations, 2012). The implementation and

achievement of the MDG in SSA encompass variabilities across national, sub-regional, and sub-national units. National variations in achievement often reflect the baseline disparities, while sub-national variations are associated with gender, socio-economical, and geographic disparities in outcomes. Finally, in 2015, a new Sustainable Development Agenda (SDA) and new goals were designed for 2030 at the UN summit (Adebowale et al., 2017; Angoua et al., 2018). However, as Darvesh et al. (2017) repeatedly noted, despite progress to minimize diarrhea-related mortality, the reduction in death and incidence has varied and unequally distributed based on SES and region types. According to the authors, various WaSH interventions have shown about 27% - 53% on diarrhea risk reduction in children less than 5, depending on the intervention type. Therefore, the authors suggested further evidence to support the scale-up of WaSH in these countries.

No studies that have addressed the current case of Cote D'Ivoire's women and their children as it related to the impact of WaSH on the mortality of children under 5 were found. This study examined the strength of the relationship between WaSH and the under- 5 mortality of the target population. This study may add insight to the current knowledge on the mortality of children less than 5 with regards to WaSH problematic. The findings of this study may help improve programs to reduce childhood mortality and morbidity and strengthen policies and practices to improve child survival in these settings.

Problem Statement

According to the World Health Organization (WHO, 2021), about 5.2 million children below 5 died in 2019, with 14,000 dying each day. When the probability of a

child dying between birth and age 5 is expressed per 1,000 live births, the rate is known as the U5MR (UNICEF, 2019 c). In the WHO African Regions, U5MR was 76.5 per 1,000 live births in 2016, a rate that is almost eight times the risk in the WHO European Region (WHO, 2018). Previous studies have shown a strong correlation between clean water, adequate sanitation, child health, and survival (Alemu, 2017; Bohra et al., 2017; Cairncross et al., 2010; Pink, 2013; World Health Organization, n.d.). The literature has found diarrheal diseases among the leading cause of mortality for children in this age range and suggested that the main route of transmission of these illnesses is associated with improper sanitation, lack of potable water, and hygiene (Angoua et al., 2018; Clasen et al., 2014; Darvesh et al., 2017; Pink, 2013; UNICEF Côte D'Ivoire, n. d.). According to the United Nations Development Programme (2018), the scarcity of clean water and basic sanitation services affects the lives of more than 40% of people worldwide. Moreover, 61.1 million of the global disability-adjusted life-years (DALYs) are attributed to unimproved water (95% UI 49.4 million to 69.6 million; 85.4% of diarrheal DALYs) and 40.0 million DALYs (36.0 million to 44.4 million) to a lack of basic sanitation services (Angoua et al., 2018). In fact, diarrheal diseases affect the lives of the most vulnerable communities with lack or/and limitation of water and sanitation including Cote D'Ivoire, a developing country located in West Africa and among the most affected groups by this burden, are children under 5 (Angoua et al., 2018).

In Côte D'Ivoire, more than eight million individuals (about 43% of its population) lack adequate sanitation sources, and more than four million still use unsafe drinking water sources, particularly in rural areas (UNICEF Côte D'Ivoire, n.d.).

According to UNICEF, in Côte D'Ivoire, many children die every day from diarrhea and other diseases associated with lack of water and adequate sanitation (UNICEF Côte D'Ivoire, n. d). As an effective control strategy, many countries have implemented the MDG water and sanitation program to address these public health issues by providing people with access to clean and safe water and sanitation sources (United Nations, 2015). The current MDG framework suggests that all countries should reduce their U5MR to no more than 25 per 1,000 live births (WHO, 2018). Despite a remarkable global decline of the U5MR by 56 percent, from 93 deaths per 1000 live births in 1990 to 41 deaths per 1000 live births in 2016; many countries (about 79 countries); particularly, SSA nations, including Côte d'Ivoire, still lag behind with a much higher U5MR of 92 per 1,000 live births in 2016 (The World Bank Group, 2018). For instance, the 2018 U5MR Sub Saharan Africa is 78 per 1,000 live births as compared to 81 per 1,000 live births in 2018 for Cote D'Ivoire (The World Bank Group, 2019), which is far higher than the average rate in the SSA regions.

Highlighted in Fink et al. 's (2011) article, the need to undertake more research to support childhood survival programs and interventions aiming at reducing childhood mortality. Even though a body of literature exists on the under-5 mortality research in general, many of these studies mainly focused on the economic analysis of the investment and its return about mortality/morbidity. Only few studies focused on morbidity and mortality associated with WaSH burden (Cha et al., 2015; Clasen et al., 2014; Diouf et al., 2014; Ezeh et al., 2014; Fink et al., 2011; Rasella, 2013). In Côte D'Ivoire, there is a need to uncover to what extent the under-5 mortality is affected by WaSH and any other

associated exposure factors. The purpose of this study was to examine the magnitude of the association between access to WaSH variables influencing the U5MR in Côte D'Ivoire. This study tried to better understand the factors that affect the mortality among children below 5 years of age. Further, the rationale of this study was that despite the MDGs recommendations that all countries should reduce their U5MR to no more than 25 per 1,000 live births (WHO, 2018), the country has yet to do so. Cote d'Ivoire still lags behind the expected target (e.g., 25 per 1,000 live births) with a huge U5MR of 92 per 1,000 live births in 2016 (The World Bank Group, 2018) and 81 per 1,000 live births in 2018 (The World Bank Group, 2019). A cross-sectional both descriptive and analytical design was expected to explain the link between exposure and their predictive effect on children under 5, using Cote D'Ivoire DHS data.

Purpose of the Study

The purpose of this study was to examine the magnitude of the association between access to WaSH variables influencing the U5MR in Cote D'Ivoire. This study focused on children under 5 because they are most affected by this problem associated with limitation or lack of water/sanitation (Pink, 2013; Christophe et al., 2007; Cairncross et al., 2010). This study used a quantitative paradigm, specifically a cross-sectional both descriptive and analytical design, to analyze Cote D'Ivoire Demographic Health Surveys (DHS) data sets containing the household questionnaires surveys data. Based on the variables measurement levels, relevant statistical methods were used, including Cox proportional hazards ratios to assess the magnitude of the relationship between variables

"access to improved water," "improved sanitation sources," and "hygiene" effect on the "under-five mortality rates" in Cote D'Ivoire. "water," "sanitation," and "hygiene" were the main predictors, and "under-five mortality rates" were the outcome variable in this study. This research may contribute to the lives of the affected population while trying to uncover the extent to which WaSH affects mortality in this age group.

Research Questions and Hypotheses

RQ1: To what extent does access to improved sanitation facilities affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$1: There is no statistically significant difference in the under-5 mortality while controlling for demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

H_A1: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

RQ2: To what extent does access to improved water sources affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$2: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

H_A2: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

RQ3: To what extent does adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$3: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

H_A3: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

RQ4: To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$4: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among

women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

H_A4: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

Conceptual Framework

The integrated behavioral model for water, sanitation, and hygiene (IBM-WASH) and the health and human rights framework are the conceptual framework for this study. Designed by Dreibelbis et al. (2013), the IBM-WaSH provides a practical and conceptual tool for understanding and assessing multilevel and multidimensional determinants of WaSH practices in infrastructure-stretched settings. The IBM-WaSH requires individual behavioral outcomes that must be taken within the wider communal and societal context where these occur. The focus of the IBM-WaSH model is on the formation of habits and behaviors not explicitly on the reduction of exposure. Hence, this approach assumes that improving WaSH practices will lead to a reduction of exposure to pathogens. The success of intervention to improve WaSH practices relies on the ability to foster and maintain behavior change at the individual, household, community, and structural levels.

The human right approach could explain the linkage between access to sanitation/water and health outcome of the affected community. This perspective applied to water and sanitation situations can enhance the health of the underserved population, in

addition to structural change pertaining to the social determinants of the health-illness-care process involved (Neves-Silva & Heller, 2016), and more specifically, the morbidity and associated mortality of WaSH related burdens on children under 5. The proposed combined framework will uncover a mix of the multiple levels of influence that may shape behavioral-level outcomes, including the three intersecting dimensions that influence WaSH behaviors (the psychological, the contextual, and the technological dimension; Dreibelbis et al., 2013). One such perceived norm influences motivation to comply and personal attitudes as determinants to various outcomes, such as consumption of potable water and routine personal hygiene; thereby, their overall influence on under-5 mortality. Using this multilevel approach will provide insights on differential compliance for preventive behaviors, self-efficacy, underlying beliefs to differential pathways, outcomes norms, attitudes/behavior, beliefs, and intentions to adopt preventive measures associated with WaSH and beyond. Overall, using the human health approach could explain the linkage between access to sanitation/water and health outcome of the affected community. This perspective applied to water and sanitation situations can enhance the health of the underserved population as well as structural changes about the social determinants of the health-illness-care process (Neves-Silva & Heller, 2016).

Nature of the Study

I conducted a quantitative study using an analytical cross-sectional study design. This correlational scientific inquiry is relevant, as it does not intend to manipulate the predictors and or assign the study participants to conditions as in experimental studies (Sullivan, 2012). However, this design statistically explored and explained the

relationship between improved sanitation, water sources, and hygiene and their influence on the under-5 death numerically and descriptively in addition to making inferences based on estimates from the sample to the population (Crosby et al., 2006; Frankfort-Nachmias & Nachmias, 2008; Szklo & Nieto, 2014).

Quantitative cross-sectional designs can rely on existing differences rather than fluctuation due to interventional effect, in addition to the fact that the selection of groups will depend on existing differences rather than random allocation, and no time dimension is a concern (USC, 2013). As mentioned earlier, the present study used a cross-sectional design for a secondary data analysis from Cote D'Ivoire pooled DHS by merging all available datasets between 2005 and 2020 at the time of analysis. So, because the DHS data are pre existing data with a known design (cross-sectional), users of such data are already driven by the preexisting design set by the primary data collectors/researchers. Based on the variable measurement levels, I used relevant statistical methods such as Cox proportional hazards ratios to estimate the strength of the relationship between WaSH (i.e., sanitation, water, and hygiene) as independent variables and potential confounders. These included: household wealth index, mother literacy level, paternal level of education, place of residence (urban versus rural), maternal education, mother employment status, number of residents in the household over the age of 5, father work status, presence of child health with the mother, child from a multiple birth, and religion, as well as child age at birth, child gender/sex, mother age at childbirth, and perceived newborn size at birth by mother (small or very small, and average or large). Lastly, the

level of U5MR was assessed as the outcome variable, while controlling for confounding and interaction effects simultaneously.

Definitions

Ezeh et al. (2014) suggested the following definitions based on WHO/ UNICEF guidelines, in this classification, both sanitation and water sources are classified as improved versus unimproved, as seen in Table 1 (Ezeh et al., 2014; Yaya et al., 2018).

Sanitation: "The provision of facilities and services for safe management and disposal of human urine and feces" (Pseau, 2016, p. 24).

Hygiene: "The conditions and practices that help maintain health and prevent the spread of disease including handwashing, menstrual hygiene management, and food hygiene" (Pseau, 2016, p. 24).

According to the CDC (2017), access to sanitation is measured by the percentage of the population with access and using improved sanitation facilities.

Improved sanitation facilities usually ensure separation of human excreta from human contact, and include the following:

- Flush or pour-flush toilet/latrine to:
    - Piped sewer system
    - Septic tank
    - Pit latrine
- Ventilated improved pit (VIP) latrine
- Pit latrine with slab

- Composting toilet (CDC, 2017, p. 1).

Yaya et al. (2018) suggested almost similar definitions for *improved sanitation facilities, seen as* pit latrines, flush/pour flush to the piped sewer system, septic tank, VIP latrine, composting toilets, and pit latrine with slab (see Table 1).

Shared sanitation facilities are of an otherwise acceptable improved type of sanitation facility that is shared between two or more households. Shared facilities include public toilets.

Unimproved sanitation facilities do not ensure hygienic separation of human excreta from human contact and include:

- Pit latrine without a slab or platform
- Hanging latrine
- Bucket latrine
- Open defecation in fields, forests, bushes, bodies of water or other open spaces, or disposal of human feces with solid waste (CDC, 2017, p. 1)

Improved drinking-water sources include standpipes or public taps, protected springs or rainwater collection, boreholes, tube wells, protected dug wells, or piped water on-premises, which refers to piped household water connection located inside the user's dwelling, plot, or yard (Yaya et al., 2018; see Table 1).

Table 1.

Water and Sanitation Sources Classified by WHO/UNICEF Guidelines

	Unimproved	Improved
Sanitation	Unimproved sanitation facilities do not ensure hygienic separation of human excreta from human contact. Unimproved facilities include pit latrines without a slab or platform, hanging latrines and bucket latrines.	Improved sanitation facilities ensure hygienic separation of human excreta from human contact. They comprise of the following facilities: Flush/pour flush to piped sewer system, septic tank, pit latrine; ventilated improved pit (VIP) latrine, pit latrine with slab, composting toilet.
Water	Unimproved drinking-water sources include Unprotected dug well, unprotected spring, cart with small tank/drum, surface water (river, dam, lake, pond, stream, canal, irrigation channels), and bottled water.	Improved drinking-water sources include public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, or rainwater collection. Piped water on premises: Piped household water connection located inside the user's dwelling, plot, or yard.

Source: (Yaya et al., 2018).

Educational level represents the number of years of education the participants attained.

Socioeconomic status represents the annual income of the study participants.

Assumptions

In this research study, various assumptions were made to address the research questions and hypotheses. I assumed that the DHS data are suitable for my study with regards to the design, methodology, and instrumentation used. I also assumed that the primary data's quality (i.e., validity and reliability) has been already evaluated and ensured in the full database and has all the variables and information needed for the current study. I also assumed that the study participants have been able to understand the meaning of the questions asked in the DHS questionnaires. Additionally, I assumed the study respondents have fully completed the questionnaire with honesty, accuracy, and

integrity. However, I am aware that social desirability, selection bias, and recall bias may have occurred. For instance, some respondents tended to consistently respond in certain ways, whether positively or negatively, or with inaccurate information due to memory lapse or recall. I also assumed that data collectors have addressed sampling biases with relevant sampling designs. Moreover, I assumed that these data were already prepared to generate available and ready-to-use survey designs and weights variables - something that many data users may not be able to do, yet this helps data users to make needed adjustments to their estimates (Cheng & Phillips, 2014).

Scope and Delimitations

The delimitations of this research include the age range, being child-bearer or caregiver /mother with children under 5 years old and residing in a household located in Cote D'Ivoire at the time of the surveys. This study used pooled Cote D'Ivoire DHS household surveys data including women of all ethnicities who strictly were considered to be of reproductive age, ranging between 15 and 49 years old, who were living in Cote D'Ivoire at the time of the surveys. Therefore, all the remaining people, both male and female aged under 15 years and more than 49 years, were excluded in this research. Given that many ethnicities were considered, the study results did not privilege one ethnicity over another. Moreover, to meet the inclusion criteria, women must be between 15 and 49 years, as such age group is within the reproductive age and must be residents of Cote D'Ivoire.

Limitations

Doolan et al. (2009) suggested that researchers interested in secondary data analysis must understand the concepts of research with regards to designing a new study, but also must be aware of challenges specific to conduct research using an existing data set. There is a huge amount of existing data, and many of them use cross-sectional designs such as huge population-based surveys (i.e., DHS data), the source of my selected data. According to Oxbridge Essay (n.d.), several limitations can challenge the use of secondary data regardless of the designs applied in these studies. These include a) the data inappropriateness for the research purposes; b) the data format may not be as expected; c) possible lack of validity and reliability of that data; d) the data may not be suitable for the new research question; and e) lack of sufficient information about their research (Oxbridge Essay, n.d.), not only data can be gathered inaccurately, but also some data can be missing.

Fortunately, the DHS data, a well-recognized data set, has been cleaned by professionals and provides detailed documentation regarding the data collection and cleaning process. It has a relatively high quality (both validity and reliability). In fact, a major challenge when dealing with secondary data including the DHS data is the fact that the data is already there with a specific form that cannot be changed, the rest is to be able to develop the research question to match with the data as well as the proper data analysis to address the research question(s) (Laureate Education, Inc., 2013c). According to Doolan et al. (2009), the challenge led by the fact that secondary data sets have been collected based on other research question(s) with different measurement strategies and

methods that are not always what the present study using them would have expected, is limiting.

One essential challenge associated with cross-sectional research using secondary data is the fact that this data has been already captured at one point in time; thus, the relationship between variables at that time (where data were collected) can fluctuate. Therefore, in such design (cross-sectional), one could miss potential or occurring relationships that may arise over time. In addition, only correlations can be assessed, no causal link can be ascertained in cross-sectional design including this study, unless further studies are conducted to assess causality between the study variables. A cross-sectional design cannot ascertain a spatiotemporal linkage between exposure-health outcome sequence (Aschengrau & Seage, 2014; Gordis, 2009; Moeller, 2011; Szklo et al., 2014).

Another limitation with secondary research in general, is that unlike in primary research where the researcher controls both the design and the implementation of the study. Having control of all the scientific protocol that is relevant for effective research. The researcher will make a choice based on his expertise, interest, purpose/objective, the research question, hypotheses, as well as the problem they want to solve in a specific target population. In contrast, in secondary research like what I undertook, this freedom is challenged by the fact that the data are already collected in a specific population (Côte D'Ivoire, DHS data) and I was not involved in that process. Hence, this process was done with a previously selected sampling strategy and research design associated with the type of study the primary investigators have planned. Therefore, as a secondary researcher

using the DHS data, I do not have control over the study design prior to frame the research questions of my study. Not being involved in that early stage of the study implementation to data collection, I may have missed any nuances in the data collection process that might help in the interpretation of results, as Cheng et al. (2014) pointed out.

Significance of the Study

WaSH related burden e.g., high U5MR, is an issue of great public health significance. This study is essential, as it will address a critical social problem, namely under 5 mortalities. This study is also significant because it examined how WaSH and other covariates (considered in this study as confounders/effect modifiers) influence U5MR; most essentially, public health officers, program planners, and government agencies may get a better understanding of this problem and its impact on the affected population's wellbeing, health, and survival. Water and sanitation-related burden threatens the lives of millions of people around the world, mainly children (Pink, 2013). Each year, 10 million children under 5 years old with about 90% of them reside in 42 of this, about 36 are in SSA (Fotso et al., 2007), including Côte D'Ivoire. In fact, 85% of diseases associated with water supply are induced through oral transmission, mainly diarrhea which leads to mortality in children (Cairncross et al., 2010). Also, diarrhea is still the main cause of mortality among children under 5 (Fotso et al., 2007; UNICEF, 2019b). Moreover, as the main cause of death for children in this age range, diarrhea (Fotso et al., 2007) has transmission pathways that are mostly linked to improper sanitation and lack of potable water (World Health Organization, n. d.) and hygiene.

Furthermore, about 90% of the decline in diarrhea and a reduction of 2.2 million in mortality rate were achieved through the provision and access to potable water and proper sanitation (Pink, 2013).

Given the public health significance of WaSH-related mortality, the MDG has proposed strategies to tackle this problem by providing improved sanitation, potable water, and hygiene education to the priority population (United Nations, 2015). The current MDG framework suggests that all countries should reduce their U5MR to no more than 25 per 1,000 live births (WHO, 2018). However, Cote d'Ivoire is still lagging the expected target (about 25 per 1,000 live births) with a higher U5MR of 92 per 1,000 live births in 2016 (The World Bank Group, 2018). To better understand the factors that affect the high mortality rates of the children under 5 in this country, a cross-sectional analytical design may examine all factors simultaneously in addition to WaSH variables as determinants to children survival using the DHS data.

The insights derived from this study may lead to positive social changes by providing public health professionals, program planners, and governmental agencies involved in children health, an additional insight and understanding of the issue of WaSH and related morbidity and mortality. Using this evidence, interested stakeholders could design interventions/programs that take into consideration all the risk factors associated with mortality in children under 5. Furthermore, the information gathered from this study may help or guide these interested stakeholders in decision making pertaining to steps to be taken to influence societies' behaviors and attitudes for better health outcomes.

Assessing and understanding the current magnitude of the WaSH effect on the under-5 mortality may contribute to reducing associated preventable morbidity and mortality. The positive social change implications for the results of the study may be to provide tangible and substantial evidence that would not only inform decision making for further planning purpose, but also help to design effective upstream population-based strategies (i.e., health education, improvement of quality of life, well-being, and survival overall) to mitigate the health burden of the affected population in Cote D'Ivoire and beyond. Using evidence from this study, public health practitioners, researchers, program planners, and funders could make informed decisions to improve the program, advocate more resources for the program, and help the affected communities in Cote D'Ivoire and other regions in need of similar interventions. Lastly, the overall outcome would be to empower the community in terms of improving their quality of life, well-being, and associated mortality and morbidity. This, in turn, would impact life expectancy, the WaSH program sustainability, advocacy needs, and survival (Parker & Thorson, 2009).

Summary and Transition

As aforementioned, this secondary analysis focused on women and their children under 5 in Cote D'Ivoire, West Africa, facing premature death associated with limitations in basic needs such as clean water, adequate sanitation, and hygiene. The finding of this research may lead to positive social changes with an in-depth understanding of how WaSH and covariates influence U5MR in Cote D'Ivoire by providing program planners, public health practitioners, and governmental agencies important insights on how to

design more effective strategies and programs to address the problems faced by the target population. I described the background for the study with a brief literature review to support WaSH and confounding factors which may influence the health and mortality of children less than 5. I also incorporated the research questions, the problem statement, the conceptual framework, definitions of terms, the purpose of the study, the nature of the study, significance, assumptions, scope and delimitations, and summary.

In Chapter 2, I provide a holistic review of available literature that summarizes the body of knowledge on WaSH and its impact on the mortality of children under 5, other risk factors, and associated morbidity. I also discuss the conceptual framework, the methods used to conduct the literature review, the literature review related to key variables and/or concepts, the justification derived from the literature and rationale to study WaSH, other contributing risk factors associated with the U5MR, and the relationship of WaSH and child morbidity and mortality.

Chapter 2: Literature Review

According to the WHO (2019), "5.6 million children under age five died in 2016, 15,000 every day" (para 1). In the WHO African Regions, the U5MR was 76.5 per 1,000 live births in 2016, which is almost eight times the rate in the WHO European Region (WHO, 2019). Previous studies have shown a correlation between clean water, adequate sanitation, child health, and survival (Alemu, 2017; Bohra et al., 2017; Cairncross et al., 2010; Pink, 2013; World Health Organization, n. d.). Some of these literatures have identified diarrheal illnesses among leading risk factors for death among children below 5 and suggested that the main route of transmission of these illnesses is associated with improper sanitation, lack of potable water, and hygiene. According to the United Nations Development Programme (2019), the scarcity of clean water and basic sanitation services affect the lives of more than 40% of people worldwide. Moreover, unimproved water conditions alone accounted for 61.1 million of the global DALYs with 95% UI 49.4 million to 69.6 million, 85.4% of diarrheal DALYs. Lack of sanitation services alone accounted for roughly 40 million DALYs (36.0 - 44.4 million; Angoua et al., 2018). In fact, diarrheal diseases affect the life of the most vulnerable communities with lack or/and limitation of water and sanitation sources, including the population of Cote D'Ivoire. Among the most affected groups by this burden are children under 5 (Angoua et al., 2018). Yet, despite a remarkable global decline of the U5MR by 56%, from 93 deaths per 1.000 live births in 1990 to 41 deaths per 1,000 live births in 2016, about 79 countries, particularly SSA countries including Cote d'Ivoire, still lag behind with a much higher U5MR of 92 per 1,000 live births in 2016 (The World Bank Group, 2018).

Only a few studies focused on morbidity associated with WaSH burden (Cha et al., 2015; Clasen et al., 2014; Diouf et al., 2014; Ezeh et al., 2014; Fink et al., 2011; Rasella, 2013).

The current study explored the magnitude of the association between access to WaSH and the under 5 mortality rates in Cote D'Ivoire. This research used a quantitative paradigm, specifically, a cross-sectional analytical design to analyze Cote D'Ivoire DHS data sets containing the household questionnaires survey data. The following sections will be discussed:

- Methods used to conduct the literature review
- Conceptual framework
- Literature review related to key variables and/or concepts
- Justification derived from the literature and rationale to study WaSH and other contributing risk factors associated with the U5MR
- The relationship of WaSH and child morbidity and mortality
- Studies about diarrhea-related burden and other covariates of WaSH.

Literature Search Strategy

The literature was searched using the following databases: MEDLINE, CINAHL, EBSCO, PubMed, Web of Medicine, Lancet, Science Direct, Sage, and ProQuest Dissertations & Theses Global. The keywords used for the literature search included: "water"; "water AND under-five mortality "; "water AND sanitation"; "water, sanitation AND hygiene", " access to improved water and sanitation sources "; and "access to improved water, sanitation, hygiene, AND under-five mortality". Papers published since

2014, in English, online and peer-reviewed journals, as well as textbooks and Walden materials, were included in this review. Papers about treatments and laboratory-based basic science were excluded. The basic key search terms are the following: water, sanitation, hygiene, under-five, water, sanitation, and hygiene-related child mortality, west Africa, Côte d'Ivoire, and risk factors associated with under 5 mortality rates among children in Cote D'Ivoire.

Conceptual Framework

Overview and Research Related to WaSH

Theories, research, and practices are applied to understand the determinants of behaviors, evaluate change strategies, and convey effective interventions (Glanz & Bishop, 2010). To address WaSH related health issues e.g., mortality among the under 5 subgroups, a combination of multiple elements must be taken into consideration context based. This is because our health outcomes have multifactorial determinants (Schneider, 2011; Wilkinson & Pickett, 2010).Thus, integrating various theories/concepts aligned with a relevant system thinking approach into a comprehensive model, encompassing an insight of the elements of each theory and other approaches, may help compensate for limitations of each individual theory in addition to uncover salient underlying determinants of child health outcomes. As mentioned in the previous section, the IBM-WaSH and the health and human rights approach for water and sanitation would be used in this study.

According to the Human Rights Councils:

> The human right to safe drinking water and sanitation is derived from the right to an adequate standard of living and inextricably related to the right to the highest attainable standard of physical and mental health, as well as the right to life and human dignity. *(*United Nations Human Rights, n.d., p. 2)

Initially established in 1977 in Argentina during the United Nations Conference on Water, the human right framework was advocated by earlier pioneers including Jonathan Mann. He suggested that the human rights framework provides a more useful approach to tackle public health challenges than other traditional biomedical references (Neves-Silva et al., 2018). At first, the United Nations General Assembly (UNGA) denied the human right for water and sanitation (HRtWS) in 2008. Then, two years after it was recognized (United Nations General Assembly, 2010) in 2010, UNGA recognized the HRtWS as vital for all humans (Neves-Silva & Heller, 2016). Access to water and sanitation has been recognized by the United Nations as a human right, as it reflects the fundamental nature of these basic needs in the life of everyone. Lack of access to affordable, safe, and sufficient WaSH sources lead to a devastating effect on the dignity, prosperity, and health of billions of individuals around the world, yet leading to substantial consequences for people to realize other human rights (United Nations Water, 2020). The approach can also make structural changes about the social determinants related to the health-illness-care process with principle based on the fact that water and sanitation are basic needs that must be accessible to anyone (Neves-Silva & Heller, 2016). According to the human rights perspective, these services are seen not only as a right for all people, but also as an obligation for the state (Neves-Silva et al., 2016).

Overall, using the human right approach could explain the linkage between access to WaSH and the health outcome of the affected community. As Ness et al. (2009) pointed out, sustainability in their development should ensure provision and accessibility to vulnerable communities to strengthen their health. The human right normative approach associated with water and sanitation comprised the following criteria: safety/quality; accessibility; acceptability; availability; and affordability. Similar criteria are employed for the human right to sanitation; for instance, the privacy and dignity were applied and tallied with people's cultural and social standards and gender-related specificities with regards to girls and women (Neves-Silva et al., 2016). The human right perspective applied to the WaSH problem can enhance the health of the underserved disadvantaged population.

IBM-WaSH is a synthesis of behavioral models associated with WaSH and organizes factors affecting behavior in an ecological framework (Hulland et al., 2013). According to Hulland et al. (2013), this model encompasses three dimensions including: contextual factors (i.e., access to water and soap), psychosocial factors (i.e., perceived risk of disease, disgust associated with contact with unclean objects, and pre-existing habit), and technological factors (i.e., related to the physical hardware storing soap and water), each of which function at five aggregate levels: interpersonal/household, habitual, societal, individual, and community/structural. IBM-WaSH can help assess behavior change programs and interventions in infrastructure-stretched settings. It contains various behaviors that change concepts and theories to provide a simple and adaptive tool to understand the formation of behavior and WaSH habits.

The IBM-WaSH Approach

The IBM-WaSH model synthesized previous behavioral models as a matrix containing dimensions (three) and levels (five), aligned with the ecological model as displayed below in Table 2.

Table 2.

The IBM-WaSH Matrix

Levels	Contextual factors	Psychosocial factors	Technology factors
Societal/Structural	Policy and regulations, climate, and geography.	Leadership/advocacy, cultural identity	Manufacturing, financing, and distribution of the product; current and past national policies and promotion of products
Community	Access to markets, access to resources, built and physical environment	Shared values, collective efficacy, social integration, stigma	Location, access, availability, individual vs. collective ownership/access, and maintenance of the product
Interpersonal/Household	Roles and responsibilities, household structure, division of labor, available space	Injunctive norms, descriptive norms, aspirations, shame, nurture	Sharing of access to product, modeling/demonstration of use of product
Individual	Wealth, age, education, gender, livelihoods/employment	Self-efficacy, knowledge, disgust, perceived threat	Perceived cost, value, convenience, and other strengths and weaknesses of the product
Habitual	Favorable environment for habit formation, opportunity for and barriers to repetition of behavior	Existing water and sanitation habits, outcome expectations	Ease/Effectiveness of routine use of product

Source: Dreibelbis et al., 2013.

The IBM-WaSH model includes three dimensions that intersect and affect WaSH constructs: the psychological dimension, the contextual dimension, and the technological

dimension (Dreibelbis et al., 2013). According to the authors, the contextual dimension encompasses factors linked to the individual, environment, and/or the setting that may affect fluctuations in behavior and the use of novel technologies. The psychosocial dimension includes the psychological, the behavioral, or the social determinants of technology adaptation and behavioral outcomes. The technological dimension implies devices or products that affect its adoption and sustained use. These dimensions interact together (i.e., contextual, technological, and psychological) and resonate with the concept of reciprocal determinism in social cognitive theory, which describe reciprocal interactions between the behavior, the environment, and the individual in which the behavior occurred (Bandura,1987). In addition, the authors suggested five aggregate levels:

1. *The societal/structural level* represents the broad cultural, organizational, or institutional factors that impact behaviors in each of the three dimensions e.g., geography, manufacturing, laws, policies, commercial, geology, and climate (Dreibelbis et al., 2013).
2. *The community level* includes the social and the physical settings where people reside and the institutions that govern societal behaviors and experiences.
3. *The interpersonal/household level* encompasses both the people and the individuals they interact with e.g., close friends, members in their households, and neighbors. Factors implicated in this level include behaviors modeling;

shame; roles and responsibilities; aspirations; household wealth; descriptive and injunctive norms; and sharing access to a product.

4. *The individual level* encompasses sociodemographic characteristics e.g., cognitive, gender, age, attitudes toward the product, behavior, or hardware.
5. *The habitual level* is the individual habits daily built repeatedly from the opportunity and necessity attached to WaSH behaviors and several influencing factors (Dreibelbis et al., 2013).

Most existing models in the literature tended to focus more on the individual level factors of the behavior, rather than a wider ecological model view that positions individual behaviors within a multi-level causal framework. However, others using a multi-level approach are restricted to the psychological-related determinants of behavior. For example, Rainey and Harding's (2005) work using the health belief model in Nepal to solar disinfection, explained how structural factors e.g., agricultural work and gender roles limit women's commitment to household water treatment. WaSH behaviors, e. g, steps to follow, when/where these behaviors must be undertaken for expected health impact, as well as factors that influence the behavior to become a habit were scarcely considered in the existing framework. However, the habit itself is an essential element for WaSH practices. Improved WaSH practices are far from one-time behavior changes, as they require substantial repetition across both space and time (Dreibelbis et al., 2013). For instance, Jenkins and Scott (2007) and Wood et al. 's (2012) frameworks are used as models to guide decision making to adopt specific technologies, unlike Wood et al.'s

models, which explicitly tackled factors associated with continued and sustained usage of technology and its maintenance.

Literature Review

The Link Between IBM-WaSH, the Human Right Approach, and Health Outcome for the Under 5

The multiple levels dimension of the IBM-WaSH framework requires that any individual behavioral outcome must be considered within the broader communal and societal context in which it occurs. The IBM-WaSH model focuses on the formation of habits and behaviors not explicitly on the reduction of exposure. Hence, this approach presumes that improving WaSH practices may reduce exposure to pathogens. Yet it is critical to have a better understanding of these behaviors' determinants independent of their direct linkage with transmission pathways (Dreibelbis et al., 2013). The success of intervention to improve WaSH practices relies on the ability to foster and maintain behavior change at the community, individual, household, and structural levels. As mentioned earlier, the human right approach to WaSH and IBM-WaSH were used in this study. The human right approach could explain the linkage between access to sanitation/water and health outcome of the affected community. This perspective applied to the water and sanitation situation can enhance the health of the underserved population, as well as structural changes about the social determinants of the health-illness-care process (Neves-Silva & Heller, 2016). Most specifically, the morbidity and mortality of WaSH related burden on children under 5. The proposed combined framework will uncover a mixed of the multiple levels of influence that may drive

behavioral related outcomes, including the three intersecting dimensions that influence WaSH behaviors (i.e., technological, psychological, and contextual; Dreibelbis et al., 2013). One such perceived norm influences motivation to comply and personal attitudes as determinants to various outcomes, such as consumption of potable water and routine personal hygiene. Thereby, their overall influence on under-five mortality. Using this multilevel approach will provide insights on differential compliance for preventive behaviors, self-efficacy, underlying beliefs to differential pathways, outcomes norms, attitudes/behavior, beliefs, and intentions to adopt preventive measures associated with WaSH and beyond. The following section encompasses the review of key variables and concepts.

Literature Review Related to Key Variables and/or Concepts

Under-5 Mortality

When the probability of a child dying between birth and age 5 is expressed per 1,000 live births, the rate is known as the under-five mortality rate (U5MR) (UNICEF, 2019 c). The Under 5 Mortality is an important indicator to evaluate the performance of a country's health system (Pedersen, Liu, & Child Mortality Estimation, 2012). Policymakers and health professionals have prioritized childhood health outcomes to combat the increasing childhood mortality rates (Adebowale et al., 2017). By doing so has prompted the creation of strategies to reduce childhood death by 2/3 among children less than five between 1990 – 2015, based upon the Millennium Development Goals.

A Brief Overview of the MDGs, the Sustainable Development Goals (SDGs), and WaSH

In 2015, it was estimated that 133 out of the 195 nations that have adopted the MDGs failed to meet the expected target of a 2/3 reduction in U5MR (Adebowale et al., 2017). Then the United Nations adopted the SDGs to ensure healthy lives and children's well-being. For instance, the "goal 3 target 3.2" is to stop preventable death in children (i.e., less than five years and newborns) by 2030 (Adebowale et al., 2017). The MDGs were adopted in 2000 and since 2001 time-bound targets for various components of development policy were set. The sanitation and drinking water targets were adopted in 2006, classified as Target 7C: "to halve the proportion of the population with no sustainable access to safe drinking water and basic sanitation between 1990 and 2015" (Bartram et al., p. 2). The SDA was developed in 2015 with new goals designed and recommended for 2030. SDG 6 focuses on water-related issues (Pseau, 2016) with eight targets such as achieving universal access sanitation, water, and hygiene services: and protecting water resources and water-related ecosystems (Pseau, 2016). The main difference between the old MDGs and the SDGs is that the SDGs focuses on sustainability, while the SDGs address sustainable development in its multiple forms e.g., economic growth, social inclusion, and environmental protection (UN, 2015); "the MDGs primarily focused on social issues"(Pseau, 2016, p.15). As Pseau (2016) pointed out, the SDGs are to be achieved in line with the implementation of this agreement. SDG 6: "Ensure availability and sustainable management of water and sanitation for all" (p.13).

As mentioned in the early section, the concepts of WaSH initiatives reflect good hygiene practice, access to improved sanitation, and water sources, critical to minimize environmental health risks for the wellbeing and health of the population worldwide (Angoua et al., 2018). Based on WHO/UNICEF guidelines, Ezeh and associates defined improved water and improved sanitation. Like Ezeh et al. (2014) and Yaya et al. (2018), Bartram, Brocklehurst, Fisher, Luyendijk, Hossain, Wardlaw, and Gordon (2014) described the measurement method used by WHO/UNICEF to classify WaSH quality and access. The authors used DHS household surveys and linear regression modeling for their analysis. Below, I will discuss the evidence-based literature that supports this study.

Justification Derived from the Literature and Rationale to Study, WaSH, and U5MR

WaSH and Associated Burdens

As mentioned in previous sections, water and sanitation-related-burden threaten the lives of millions of people around the world, mainly children (Pink, 2013). Yet annually there are about 10 million children less than 5 years old with about 90 % of them residing in forty-two nations of this, thirty-six from SSA (Fotso et al., 2007) including Côte D'Ivoire. According to Adebowale et al. (2017), the U5MR is highest in SSA with 1/12 deaths during the first 6 months of SSA child, 12 times more than the 1/ 147 in developed nations. About 85% of diseases associated with water supply are induced through oral transmission, mainly diarrhea which leads to mortality in children (Cairncross et al., 2010). As mentioned in the introduction, there is a linkage between

diarrheal diseases, WaSH, child morbidity, and mortality. Diarrhea remains the main risk factor of death in children below age five (Darvesh et al. ,2017; Fotso et al., 2007). Its transmission pathways are mostly associated with improper sanitation and lack of potable water (Angoua et al., 2018; Pink, 2013; World Health Organization, n. d); as well as poor hygiene. Some studies have revealed that about 90% of the decline in diarrhea and a reduction of 2.2 million in mortality rate were achieved through the provision and access to potable water and proper sanitation (Pink, 2013). For instance, various WaSH interventions indicated a reduction of risk for between 27% and 53% in children less than 5 years old depending on the type of intervention used (Darvesh et al., 2017). Finally, the authors suggested further research must be undertaken to evaluate these interventions' impacts in different contexts. This approach is also supported by many authors including Alemu et al (2017) and Angoua et al (2018). From Gorham and associates' (2017) view, diarrheal illnesses are the underlying cause of death for approximately1.5 million people globally in 2012. About 502,000 annual deaths are attributed to poor WaSH conditions in low/middle-income countries; this represents more than half (58 percent) of cases-specific related deaths (Gorham et al., 2017).

Factors Explaining the High Mortality Rates in Africa Water and Sanitation

WHO/UNICEF suggested that poor sanitation and water cause about 28% of child mortality and adequate water and sanitation sources were not only cost-effective , but also proven interventions (Alemu, 2017). According to Alemu (2017), about 9 in 10 diarrheal incidence cases could be averted with proper water and sanitation use. The use

of proper toilets can drop incident diarrhea by approximately 40%. Moreover, proper sanitation can substantially reduce the main risk factors for child death, including pneumonia and undernutrition. Hence, tackling issues related to access to sanitation is important to minimize the mortality rate by 2/3 in childhood (Alemu, 2017).

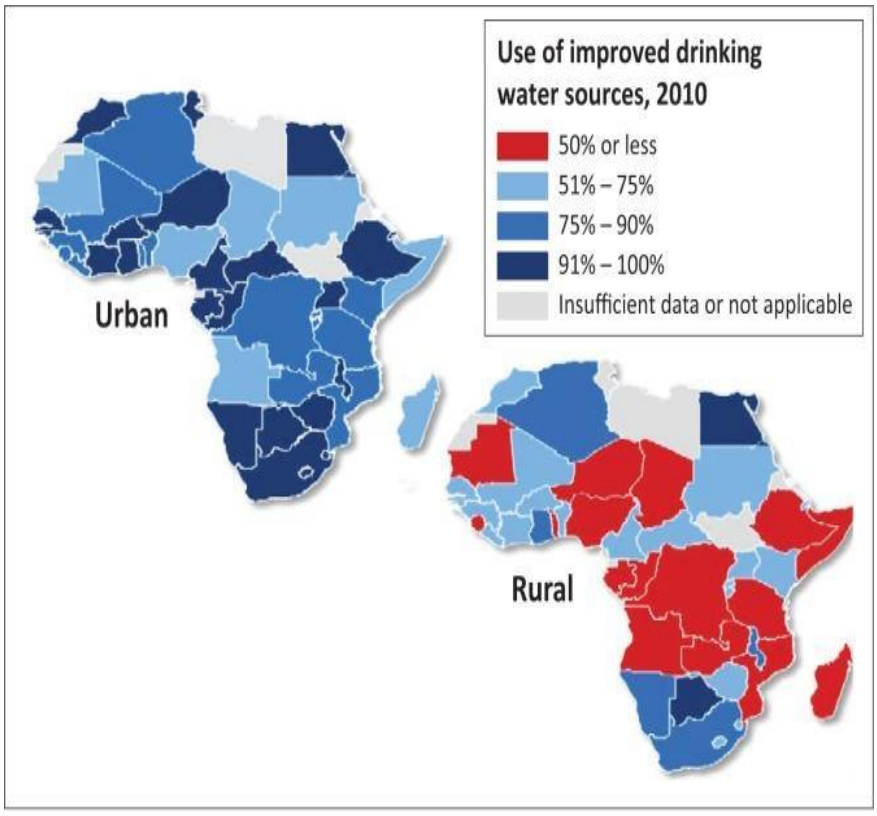
These paragraphs account for the disparity in socioeconomic status (SES); geographic setting (rural versus urban; slums, war zones); the difference in access, availability, and quality of WaSH; diarrhea diseases; other infectious diseases; and policy implications. Several factors are implicated in the access and the differential outcomes of WaSH related burdens. Given the new MDGs targets of SDGs, the interaction between improvement in children's health and non-health fields have been increasingly recognized. Hence, WaSH interventions (i.e., improvement of access to good WaSH) to provide opportunities to enhance the well-being and health of children through preventive actions such as improvement of their nutritional status and halting the transmission of communicable illnesses (Darvesh et al., 2017). In convergence with this perspective, Angoua et al. (2018) suggested that rural exodus, poor socioeconomic conditions, and geographic settings predict access to water and sanitation (WS). As the authors pointed out, people residing in poor peri-urban communities in SSA cities are still challenged by access to WS.

Alemu (2017) expressed similar views regarding the differential level of access to WS sources based on geographic setting comparing several African countries. From the WHO/UNICEF (2012) assessment, progress made by Africa with regards to access to basic sanitation is still low and limited. From 1990 to 2010, about 35-40 % increase in

access to sanitation was done with a gain of 189 million with access (Alemu, 2017). With the huge population growth, the urban population has doubled between 1990 to 2010, more than 1 out of 4 people rely on public or shared sanitation sources in urban zones. As the author pointed out, in Africa, Egypt, Namibia, Botswana, and South Africa are the only nations to achieve about 91 to 100 % coverage level of improved drinking water use nationally. However, the most striking is the disparity between rural versus urban populations with regards to access to WS. For instance, as Alemu noted , with a manifest graphical display, despite having a higher population in almost all African nations, rural settings are still lagging behind to get access to clean drinking water as shown in Figure 1 below (Alemu, 2017).

Figure 1

Use of Improved Drinking Water in Urban and Rural African Countries in 2010



Note. For more details see Alenu (2017). *African Journal of Primary Health Care & Family Medicine, 9*(1), 1370. http://doi.org/10.4102/phcfm.v9i1.1370.

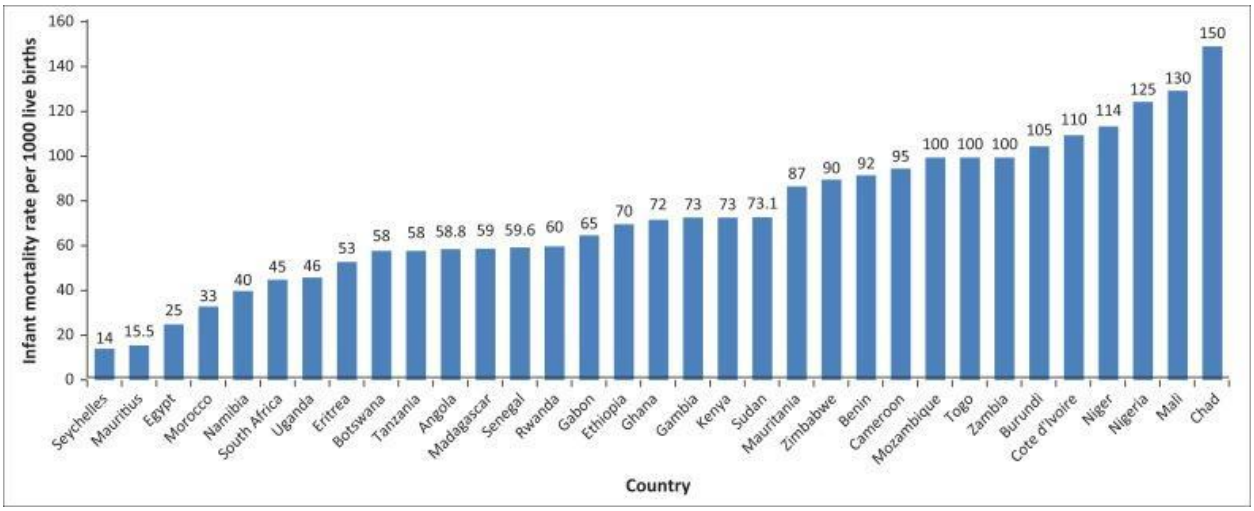
The Link Between the Use of Sanitation in Selected African Countries and IMR, Under 5 Years Old in 2010

In Figure 2 and 3, Alemu (2017) compared the rates of child mortality per 1000 lives of birth and improved sanitation sources level in 2010 for about 33 African nations. In Figure 2, Egypt, Namibia, Seychelles, Morocco, Mauritius, and South Africa are classified as top nations with a substantial reduction of their IMR and U5MR. Seychelles,

for instance, IMR per 1000 live births is about 14, while in contrast, countries such as Niger, Chad, Nigeria, Mali, Burundi, and Cote d'Ivoire have a higher IMR (Alemu, 2017).

Figure 2

Infant Mortality Rate per 1000 Lives of Births in Africa in 2010.



Source: Alemu (2017)

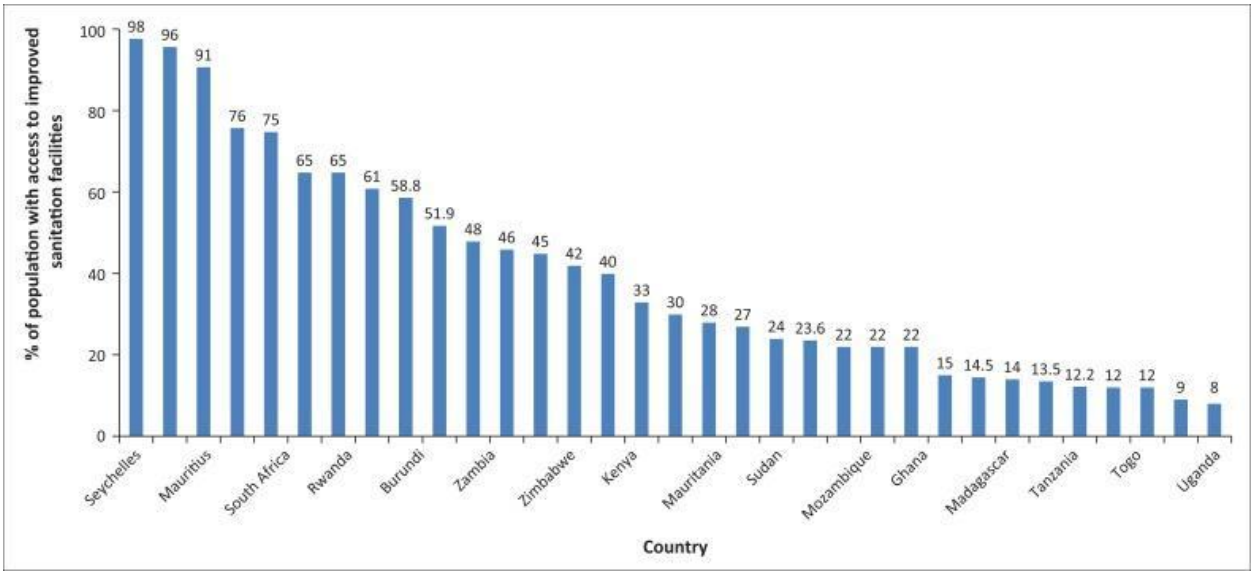
Link Between the Use of Improved Sanitation in Selected African Nations and IMR, Under 5 Years Old in 2010

Similarly, Figure 3 showed the magnitude of improved sanitation in the most successful African nations e.g., Morocco, Egypt, Botswana, Seychelles, Mauritius, and South Africa that have had substantial progress. However, Chad, Uganda, Eritrea, Benin, Togo, Niger, Tanzania, and Madagascar had the worst level of achievement for access to sanitation (Alemu, 2017). In a similar perspective, Angoua et al. (2018) examined the magnitude of access to proper WS facilities in Abidjan and assessed factors associated

with accessibility. According to the investigators, while 91.5 % of the urban population can access improved drinking water, only 31.7% can access improved sanitation sources.

Figure 3

Improved Sanitation Facilities (percentage of population with access) in Africa in 2010



Source: Alemu, 2017.

In addition to the factors described above, socioeconomic conditions and the socio-political crisis of the population influence WaSH and associated morbidity and mortality (Angoua et al., 2018). For example, the increasing urbanization rate, the recent civil war, and the rural exodus of the population in Abidjan have had a huge impact on the population's well-being and overall health. Moreover, due to the extreme poverty of rural inhabitants, they often move from rural areas into cities for a better livelihood. According to WHO, UNICEF (2014), conditions of life, access to water, sanitation, and infrastructures are bad in rural places compared to cities. Despite substantial progress, both uneven and steady, about 96 % urban versus 84 % rural used improved water

sources; while 82 % of urban versus 51 % rural population used improved sanitation in 2015 (Darvesh et al., 2017).

For all these reasons described above, Angoua and associates suggested more innovative planning approaches tailored to each population characteristics, needs, and conditions context-based, for speed progress in accessing WS by 2030 as recommended by the SDGs. Therefore, these strategies must implicate the following: local administrative authorities, religious communities, and WaSH. While the dire studies indicated meaningful information for child survival overall in Africa; yet the burden caused by the huge rate of U5M in Cote D'Ivoire needs to be examined and understood (Anguan et al., 2018).

Diarrhea is One Main Causes of Death Among Children Under 5

As mentioned repeatedly, diarrhea is one main cause of mortality and morbidity in childhood (Darvesh et al., 2017; Pink, 2013). Diarrhea is in fact, classified as the second predictive morbid risk factor among children below five (Baker et al., 2014). Poor WaSH conditions are the primary exposure pathways for infection. Most particularly, in disadvantaged regions, about 3/4 million children are killed by severe dehydration associated with diarrhea occurrence. Often diarrhea can induce long-term damage to the gut, growth stunting, and malnutrition (Baker et al, 2014). The enteric pathogens of diarrhea (i.e., bacteria, viruses, and parasites) are transmitted through poor hygiene and/or infected drinking water or food. As Baker and associates suggested, improving conditions in WaSH may more likely minimize risks of exposure to infectious agents and reduce

incident diarrhea in childhood. For instance, about 36 % decline in diarrhea risk is associated with improved sources of sanitation (Baker et al., 2014). The same view is also supported by Darvest et al. (2017). Similarly, to the above view, Darvesh et al.(2017) added that poor WaSH status and interventions can affect children development and growth in many ways and is consensually acknowledged that without improving WaSH conditions, improvement in undernutrition would not be feasible for the disadvantaged children around the world. Below, I discuss several studies about diarrhea-related burdens and other covariates of WaSH.

Studies About Diarrhea-Related Burden and Other Covariates of WaSH

In this quantitative study, Alemu (2017) conducted a study aimed to examine the magnitude of the IMR under-five age empirically and systematically across African nations in relation to improved sanitation accessibility .The investigator enrolled a total of 33 nations between 1994 to 2013 in Africa. Using Durbin–Wu–Hausman specification test, fixed-effect model, and Praison–Winsten regression with corrected heteroscedasticity, the researcher verified results consistency (Alemu, 2017). The author found out two IMR was averted when access to improved sanitation is increased to 1% .Substantial decrease of IMR was highly associated with improvements in education, health, and sustainable economic growth. While Alemu's study focused on the accessibility of improved sanitation in Africa, the following research by Fink et al. (2011) has examined access to WS and child health. Taking into consideration both independent

variables, more holistic results could be found pertaining to the determinants of child mortality and WaSH related issues.

In their research, Fink, and associates merged DHS data with water and sanitation information containing complete birth histories of children captured in these surveys. Using logistic regression, the authors measured the impact of WS on both infant and child death, stunting, and diarrhea. They found lower mortality with improved sanitation (OR = 0.77), a lower risk of diarrhea (OR = 0.87) and a lower risk of mild or severe stunting (OR = 0.73). In addition, a lower risk of diarrhea (OR = 0.91), a lower risk of mild or severe stunting (OR = 0.92) were associated with access to improved water (Fink et al., 2011). This study indicated slight protective effects (point estimates) than reported estimates in the literature. Moreover, these results strongly underlined a significant health impact of children in low-and middle-income nations without access to water and sanitation (Fink et al.,2011). The results can be understood as infant children generally get most of their nutrition from breastfeeding; hence, this may probably minimize their direct exposure to the effect of sanitation and water. These two groups of the literature showed convergent results in the sense that both indicated a direct association between sanitation and child mortality (under 5), with a negative correlation between U5MR and accessibility to improved sanitation.

Unlike the literature above, Darvesh and colleagues (2017) were interested in intervention on WaSH and its impact on childhood morbidity. Using a systematic review Darvesh and colleagues assessed the impact of WaSH programs and diarrhea in children below five. They found in the pooled analyses, a decrease in incident diarrhea in point-of-

use water filtration (RR: 0.47), point-of-use water disinfection (RR: 0.69), and hygiene education (RR: 0.73). High heterogeneity levels were observed in pooled analyses. In addition, improvements to water disinfection and the water supply at source have not shown a significant risk of diarrhea, "nor did the one eligible study examining the effect of latrine construction" (Darvesh et al., 2017, p.1). Various WaSH interventions have indicated about 27% to 53% on diarrhea risk reduction in children less than five. The authors suggested further research to examine the impact of these programs accurately and context based (Darvesh et al., 2017). Hopefully, longitudinal studies may bring some more light in these interventional outcomes.

Unlike the above, the following study related to diarrhea is more experimental (a cluster-randomized trial: CRT) to explore the impact of school-based WaSH programs on outcomes associated with diarrhea among children (younger siblings of school-going children). Dreibelbis et al. (2013) conducted a CRT during 2007-2009, with the enrollment of 185 schools in Kenya. The authors assigned to schools (based on the availability of water) of two study groups. Using logistic regression estimated changes between groups (Dreibelbis et al., 2013).The authors found out, among water stretched schools, improvement in WaSH holistically were linked to a reduction of the odds of diarrhea (odds ratio [OR] = 0.44; 95% confidence interval [CI] = 0.27, 0.73) and visiting a clinic (OR = 0.36; 95% CI = 0.19, 0.68), relative to control schools (Dreibelbis et al., 2013). There was no statistical difference in the groups with high access to water; water treatment interventions; school sanitation improvements; and school hygiene promotion was not linked with differences in prevalent diarrhea between control and intervention

schools (Dreibelbis et al., 2013). Finally, the investigators concluded that in water-stretched places, intervention for WaSH in school with robust water facilities improvements can minimize diarrhea illnesses in childhood (Dreibelbis et al., 2013).

Similarly, to the above, the Human security perspective suggested that water, sanitation, and the health of children is correlated (Pink, 2013). Other literature supports this worldview including Alemu (2017) who noted that access to improved WS are necessities for all humans and this could have saved millions of infants from death before reaching five years and beyond. Additionally, such improvement can reduce disparity towards gender and vulnerable people. Yet, improper sanitation and open sewage systems often severely contaminated sources of water leads to waterborne illnesses and death (Pink, 2013). Given these pieces of evidence, many water- stretched countries have incorporated water and sanitation programs to their health promotion effort in their development goals and plans. For instance, The Millennium Development Goal 4 (MDG4) provides strategies to tackle the issue, reduce the morbidity, and mortality among affected children ; by scaling up and promoting targeted programs. Providing and making access to WaSH programs could promote health and the wellbeing of vulnerable communities (United Nations, 2015). These programs should be considered as a control measure: primary and primordial preventative strategies that may alleviate the onset of waterborne and foodborne diseases, and related premature death of affected communities (United Nations, 2015). However, to be effective, such programs need to identify and target appropriate risk factors, risky behaviors, and vulnerable individuals

(CDC, 2012) and populations. Some examples of interventions about WS are presented in several studies below.

The Relationship of WaSH and Child Morbidity and Mortality

The following research focused on the impact of WaSH and diarrheal diseases among children. Using a cross-sectional survey, Diouf et al. (2014) examined prevalent diarrhea and related exposure factors among children below 5 in rural Burundi. The authors enrolled 903 children living in 551 households. Their results indicated that 33% of children had diarrhea,46% used improved water facilities, and 3% had access to improved sanitation. The authors found a lower prevalence of diarrhea among those linked to caretakers with education in hygiene (18%), and boiled water (19%). In sum, they concluded that the prevalence of diarrhea can drop through hygiene education and household water treatment. Therefore, they suggested an ongoing hygiene education in households and communities for a greater impact on children's health (Diouf et al., 2014).

Rather than a correlational design, a prospective design was used by Gorter et al. (1998) to investigate the influence of hygiene practices on diarrheal diseases in children less than two years old in rural Nicaragua. They selected 172 families (about 50 percent had children experienced higher diarrhea rate and 50 percent with a lower rate) and observed hygiene behavior over two mornings and recorded an episode of diarrhea weekly for five months. The investigators found that diaper/underclothes, domestic cleanliness, and hands washing had the highest protective effect. Better economic position (i.e., possession of radio) and schooling (>3 years of primary school) had a

positive impact on general hygiene behavior. The presence of radio leads to a slightly stronger effect. Finally, the researchers consistently found a linkage between almost all hygiene practices and diarrhea, more years of education were associated with better hygiene behavior (Gorter et al., 1998).This study resonates with previous literature with regards to morbidity such as diarrhea incidence and its association with hygiene behaviors, based on SES and education.

The following study by Messou, Sangaré, Josseran, Le Corre, and Guélain (1997) took place in Cote d'Ivoire. The researchers compared two groups of villages to explore compliance influence and hygiene, water facilities: and oral rehydration for diarrheal diseases among children less than 5 in four villages. The researchers compared children's diseases and death rates in two groups of villages (with and without intervention) before and after the intervention. Baseline survey provided data on diarrhea incidence and mortality rates. The authors found a 50 % reduction of diarrhea incidence rate and 85 % reduction of death associated with diarrhea in the intervention villages. Hence, they concluded that access to improved water and hygiene played a critical role in preventing diarrhea among children (Messou et al.,1997).

A similar study was conducted by Rasella (2013) in Brazil to examine the Water for All Program (PAT) program impact in 224 counties. The aim of PAT is to expand WS sources coverage in areas with high exposure vulnerability to waterborne illnesses. The author compared data collected before-and-after interventions from 2005 to 2008 and found out that coverage of PAT was inversely linked ($p < 0.01$) to the U5MR. Countries with a PAT coverage over 10 percent had a reduction of 39 percent ($p < 0.05$) in

mortality from diarrhea, U5MR of 14 % ($p < 0.01$), and hospitalizations induced by diarrhea of 6 percent ($p < 0.05$) when compared to counties without PAT or with lower coverage. Therefore, the investigators concluded that in highly vulnerable settings programs for water and sanitation could have a significant influence in reducing health inequalities. This resonates well with previous literature as Angoua et al. (2018) emphasized earlier. In a conclusive tone, Angoua et al. noted that despite all the progress done to achieve access to safe WS sources; still these elements are still challenging for SSA nations.

In an attempt to explain what triggers access to WS in these regions, Angoua et colleagues through a correlational study examined the ability to access improved sanitation and water in urban settlements habitants to identify factors that predict access to guide to address environmental risks and associated health issues (Angoua et al., 2018). The authors undertook a cross-sectional study design in six poor settlements of Yopougon. They randomly selected 556 households through logistic regression modeling to explore potential links between access to improved water /sanitation. They found out that about 25 % of all households did not have access to clean water and 57 % without improved sanitation. In peri-urban areas, characteristics of these settlements and socioeconomic status were the main predictors for poor access to reliable sanitation and water services. In addition, having a household head's spouse was 3.57 more likely to get access to clean water than the absence of a household head wife; hence, emphasizing the importance of women in sustaining clean water at home in these particular areas. In sum, the authors suggested that women should be engaged at all levels of programming for

promoting water in these places to enhance the population's well-being. While religion does not appear to play an important role in access to sanitation and water; successful "interventions should involve religious communities because of their large representation" (Angoua et al., 2018, p.1).

Similar research took place in Kenya, by Bocquier, Beguy, Zulu, Muindi, and Konseiga (2011). In this research, the investigators examined the impact of child migration and mother on children's survival (more than 10,000) residing in informal congested settlements (slums) in Kenya, without inadequate access to health care, safe water, sanitation, and other social services. Their results showed slum -born children have a higher mortality rate compared to non-slum-born counterparts. Furthermore, slum-born children at migration time, have the highest mortality risk. Despite the similarity in the SES of the study population in different geographic settings; however, while the previous study focused on poor peri-urban settlements in West Africa City (Abidjan, Côte D'Ivoire); the study of Bocquier et al. (2011) has explored survival (through child mortality rates) among slum-born children compared to non-slum-born in Kenya.

Angoua et al. (2018) have examined accessibility to WS in Cote D'Ivoire, however, they restricted their study on water and sanitation alone. Expectably, by exploring morbidity and or mortality, a subsequent endpoint could have been very insightful for my study.

Other studies assessed the contribution of the effects of political, economic, social, economic, health programs, policy, and health systems in reducing U5MR (Feng et al., 2012). This study examined secondary data on China Health Statistics Yearbook

data (from 1990-2006) in 30 Chinese provinces. They conducted regression models to assess the effect of thirty-five factors and five constructs defined by factor analysis. The result indicated that China U5MR has declined from 65 to 21 per 1000 live births and achieved the MDG4 nine years earlier. The five constructs examined, predict about 80 % of the variability in mortality rates among children less than five across provinces over the seventeen years period (Feng et al., 2012).

Finally, the authors concluded that health systems strengthening, and vertical interventions or growth are insufficient to reach expectations in reducing child death while improving key social determinants of health still lagging. Therefore, to improve progress toward MDG 4, a cross-sectoral approach (e.g., improving access to safe sanitation, clean water, and promoting maternal education) may more likely lead to the greatest impact on U5MR in low- and middle-income countries (Feng et al., 2012).

In Kenya, similar research was undertaken by Garrett et al. in 2008. The researchers compared the rates of diarrhea in 960 under-five children in 18 randomly selected villages (six comparisons versus 12 intervention) and 556 households. Over an 8-week period, the authors conducted home visits every week to evaluate the effect of the household latrine, water treatment, shallow wells, and rainwater harvesting on incident diarrhea among children less than five. Multivariate analysis indicated that living in an intervention village, using rainwater, and the presence of latrine, were independently linked to minimal risk for diarrhea. Diarrhea risk was higher among shallow wells users. In sum, the researchers concluded that using latrines, rainwater, and chlorinating stored

water minimized the risk of diarrhea and that combining interventions may improve health outcomes.

Rather than a simple observational design, Cha et al. (2015) work was experimental; most specifically, a cluster-randomized study design undertaken in Ghana. Such designs could have a lesser threat to validity when careful and rigorous protocols are followed. In fact, the authors conducted this research to explore the impact of improved water services on prevalent diarrhea in children below five years in Ghana. Studies exploring the influence of improved water sources; mostly inadequately used randomized trials or observational designs. As described in the early section, Cha et al. (2015) used a modified Poisson regression to measure the prevalence ratio, coupled with an intention-to-treat analysis. Overall, the results showed that improved water sources are more likely to decrease diarrhea risk by 11% in children less than five (Cha et al., 2015). Their study has been instrumental in shedding some light regarding the matched cluster randomized control trial, with a careful methodological approach to convey the evidence to support their findings. However, it only focused on incident diarrhea as the outcome; while hopefully, I would have expected to go further by assessing some final endpoints e.g., mortality. Hence, not to be restricted to water sources only, but sanitation, hygiene, and all potential exposure factors captured in the DHS data for instance.

Summary and Conclusions

The review of the literature about WaSH and associated risk factors on U5MR revealed the public health significance of the problem, its magnitude, its economic , and

social burden associated with high disparities based on geographic setting and socio-economic conditions of the affected population. Thereby, the reasons why WaSH needs must be addressed through access and provision to adequate sanitation, clean water, and hygiene. In fact, the literature showed that lack and limitation of water and proper sanitation; as well as subsequent contributing factors e.g., lack of proper hygiene was among exposure factors repeatedly associated with the high U5MR and morbidity in children below 5 mainly in disadvantaged places located in Asia, Latin America, and Africa .As mentioned in the early section, globally, lack and limitation of water affects more than 40 % of the population, an alarming figure that is expected to increase with the effect of global warming .This alarming public health problem poses a serious threat to the life of the local population; most particularly, children.

In sum, these studies have relevant insightful evidence derived from meticulous designs (i.e., cross-sectional descriptive and analytic; experimental, RCTs; systematic review; and meta-analysis). Yet the current review will not only inform the choice of my research methodology, design, methodology, and analysis, but also, will examine other risk factors besides WaSH e.g., diarrhea, the geographic settings, SES, geographic settings, and sociodemographic characteristics that may influence U5MR. Not only the literature above focuses on young children (under 5), their burdens such as morbidity related to access to poor WaSH , but also, most of them use a quantitative paradigm with programs/interventions provided to the disadvantaged communities of Asia, Latin America, and Africa. Although, the majority of these findings are not directly from Cote D'Ivoire (the setting of the current study); yet, they provided insightful information about

the magnitude, the public health significance, the risk, and contributing factors associated with U5MR; and the impact of involved interventions/programs on the health and well-being of the target population. The review above showed the discrepancies related to the high death rates in children under 5, WaSH, and other risk factors in Cote D'Ivoire. However, it is still unclear how to link the high mortality rates in Cote D'Ivoire despite all the efforts done to minimize this issue of public health importance.

Chapter 3 discussed the study method, design, and rational; sampling and sampling procedure; the target population; and data collection procedures e.g., ethical procedure, data gathering or access to the secondary data; and threats to study validity.

Chapter 3: Research Method

Chapter 3 describes the study design and rationale; the research methodology; the study population; the setting; the recruitment strategy; the sample size estimation through power analysis; the inclusion and exclusion criteria; the research questions and hypotheses; the sampling method; the instrumentation and materials; the study variables; access to DHS data; and statistical analysis plan. The section also introduces and addresses potential threats to the study validity and provides a thorough explanation of related ethical procedures and introduces Chapter 4.

Research Design and Rationale

Research methods and designs are critical elements to consider during the planning, design, and implementation of the research study. The current study was a secondary analysis using pooled Cote D'Ivoire DHS data by merging all available data sets from 2005-2020 at the time of the analysis. The goal of this quantitative study was to examine the magnitude of the association between the dependent variable (the mortality of children under 5 years old) and the independent variables (access to improved water sources, access to improved sanitation sources, and hygiene).

In this study, DHS surveys data and questionnaires, including the standard household questionnaires through individual interviews with mothers about their socio-demographics, socio-economic characteristics, their health behaviors, and health outcomes; particularly related to their children under 5 years was used. Quantitative inquiry is pertinent, as this approach can include measures (questionnaires) that these mothers can answer for instance, the full birth histories of their children, information

about access to water, sanitation, and hygiene, and several covariates captured in the pooled DHS data.

Additionally, in cross-sectional designs, all variables are captured at once (Creswell, 2014). Often the design of a study drives data collection methodology and data analysis; hence, users of such data are driven by the preexisting design set by the primary data collectors/researchers and in fact, DHS captures data using a cross sectional design. For instance, the proportion of those exposed and those not exposed to quality WaSH variables and all other exposure factors captured in the DHS data will be measured to describe the study population by the magnitude of death among children under 5 associated with the above risks, by time and geographic setting.

Moreover, this quantitative analytic cross-sectional approach can make inferences to the population based on the estimates found from this quantitative inquiry. Unlike traditional (gold standard) experimental designs, in cross-sectional designs, there is no need to perform manipulation on the independent variables. In addition, there is no need to assign to the study participants the measured conditions presumably seen as the effect of the predictors on the dependent variable inferentially. One benefit of employing a quantitative cross-sectional is that such designs can rely on existing differences rather than fluctuation due to interventional effect, in addition to the fact that the selection of groups will depend on existing differences rather than random allocation, and no time dimension is a concern (USC, 2013). Quantitative methods can also provide numerical analysis for a deductive system worldview. Furthermore, with quantitative methods, biases, systematic errors, confounding, and interaction factors could be minimized or

controlled in many ways, whether at the design stage and or at the analysis stage through weighing adjustment, stratification, and use of multivariate analysis (Pike, 2008). As Pike (2008) suggested, through weighting adjustments, researchers can compensate for biased estimators led by survey nonresponse. Following this perspective, using this design (cross-sectional), I can still make an adjustment through weighting to compensate for nonresponse rates and missing data in this data set (the DHS). In an analytical cross-sectional approach, I conducted a survival analysis such as cox proportional hazard method to minimize biased estimators while adjusting for any spurious variables (i.e., confounders and effect modifiers) so that more accurate estimates could be achieved with more valid and reliable results associated with high replicability and generalizability (Health Knowledge.org, n.d.). Furthermore, cross-sectional designs are relatively less expensive, easy to implement, and a time-saving approach as compared to sophisticated experimental designs, e.g., RCTs.

I looked at the level of access to WaSH and all confounders and or interaction variables simultaneously in the study population, women, and their children under 5 exposed to such environmental risk factors. Therefore, as mentioned earlier, the cross-sectional designs are relevant for such an objective to measure trends and strength of the association between the independent and the outcome variables involved in this research study both descriptive and inferential. In fact, this design helps for the advancement of knowledge in the realms of the social sciences by providing a basis to describe patterns of association or correlation between variables (Frankfort-Nachmias & Nachmias, 2008). Moreover, the quantitative cross-sectional design helped to enroll a large sample size in

this study which may increase the research external validity and power (Burkholder, n. d.; Crosby et al., 2006; Ellis, 20110; Forthofer et al., 2007; Frankfort-Nachmias et al., 2008). Using a cross-sectional design, I examined the strengths of the relationship between the study variables and examined the determinants of U5MR in order to further contribute to the knowledge about WaSH and other contributing risk factors that led to the huge U5MR. Despite all the advantages of this design, as a correlational design, cross-sectional studies present some weaknesses in the sense that they cannot ascertain a temporal linkage between outcome and predictors variables, so causation cannot be assessed effectively in such designs (Frankfort-Nachmias et al., 2008; Sullivan, 2012; Szklo & Nieto, 2014).

The goal of this correlational study is to uncover how and to what extent the under 5 mortality is affected by WaSH. The rationale behind this research study is distinctive as it aims to tackle an under-researched subject in public health realms focusing on the experiences of affected mothers pertaining to the loss of their children before reaching 5 years old —*more particularly, among* the female strata of the population at reproductive age, ranging from 15-49, who have been *underrepresented* in the literature, and those disadvantaged populations who may be disproportionately affected in various instances e.g., gender, health, and SES. The main purpose of this quantitative cross-sectional study is to address the research questions below:

RQ1: To what extent does access to improved sanitation facilities affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$1: There is no statistically significant difference in the under-5 mortality while controlling for demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

H_A1: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

RQ2: To what extent does access to improved water sources affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$2: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

H_A2: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

RQ3: To what extent does adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$3: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

H_A3: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

RQ4: To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$4: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

H_A4: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

Methodology

This study used a quantitative correlational method, specifically a cross- sectional design, using pooled data from several DHS survey years between 2005 and 2020 by merging all available data sets at the time of the analysis.

Population

Cote D'Ivoire is in Western Africa, bordering the North Atlantic Ocean, between Liberia and Ghana. Its current population is 27,481,086 people with a population growth rate of 2.26%. In 2018, this country had about 25,009,229 (Central Intelligence Agency, n.d.). The population of Cote D'Ivoire was about 18,354,514 in 2005 and 22,6 million people in 2011 with a growth of 2.6% and more than 60 ethnicity categorized in five big groups (National Institute of Statistics, & ICF International, 2012). Life expectancy is about 61.3 years for the total population with a death rate of 7.9 deaths/1,000 population and ranked 93rd in the worldwide comparison (Central Intelligence Agency, n. d.).

Sampling and Sampling Procedures

The present study enrolled all women between 15 and 49 years who were living in Cote D'Ivoire at the time of the surveys; hence, all the remaining people e.g., age ranging under 15 and those more than 49 years old were automatically excluded from this research. The selected participants were interviewed in their house regarding their childbirth story, number of children under 5, child's birth date, child's survival status, reason for child's death, and child's age at death.

The Sampling Strategy and Design

Scientific sample surveys are a reliable and cost-efficient approach to gather population-level data e.g., demographic, health, and social data. The MEASURE DHS project is a worldwide project implemented by many various countries and at various points in time within a country. To reach best quality, consistency, and comparability in

survey results, sampling activities in the DHS are being guided by several general principles. The key principles of DHS sampling include:

- Use of an existing sampling frame
- Full coverage of the target population
- Use probability sampling
- Use an adequate sample size
- Use the simplest design possible
- Conduct a household listing and preselection of households
- Provide good sample documentation
- Maintain confidentiality of individual's information
- Implement the sample strictly as designed (ICF International, 2012a).

This study used quantitative sampling such as a cluster sampling design in which the unit of sampling is a group of population elements (not a single element of the population). The unit of the sample encompasses all those align with the inclusion criteria of the study (Frankfort-Nachmias et al., 2008), and this is expected to be households with at least one woman (a mother, a caregiver, or child-bearer) ranging from 15-49 years old living there in Cote D'Ivoire. To better assess the magnitude of the relationship between WaSH on children under 5 years' mortality, the most reliable source of information is the caregivers (often mothers) and or any childbearing women between 15 and 49 years old, living in randomly selected households at the time of the surveys.

Frankfort-Nachmias et al. (2008) suggested that the sampling design affects data gathering and quality. Quantitative sampling such as a multistage cluster sampling design

was the most relevant method for this research to examine a representative mortality rate for the country. According to Johns Hopkins Bloomberg School of Public Health (2009), cluster sampling is also relevant for huge-scale studies. The cluster sampling is appropriate and cost-efficient with a sampling frame readily available at the level of the cluster. This design is less time consuming and suitable for institutional surveys, as well as for listing and implementing. A stratified two-stage cluster design was the sampling design employed for DHS. A two-stage cluster sampling procedure in which the cluster represents a group of adjacent households which serves as the PSU for field work efficiency. Often a cluster is an enumeration area (EA) with a measure of size equal to the number of households or the population in the EA, drawn from the population census (ICF International, 2012a).

The first stage (at the EAs) is often derived from Census files, the second stage in each EA selected, and a household's samples drawn from households list (Demographic and Health Surveys, 2018). Moreover, the sample is generally representative of both the national, residential (rural and urban), and regional (states and departments) levels (Demographic and Health Surveys, 2018).

Steps for Sampling and Sample Size

- A random selection of a representative group of districts (from the most recent list) of the Cote D'Ivoire ministry of interior was done first,
- Then, a random selection of representative villages/blocks from every selected district was done,

- Then, a random selection of a representative number of households in selected blocks/and villages,
- Finally, an interview of all women from 15 – 49 years in their home.
- A power analysis will help to compute the minimum sample size to expect a statistically significant result (Ellis, 2010; Lakens, 2013). Because the DHS surveys have huge sample sizes (between 5,000 and 30,000 households) (ICF International, 2012b), I used the complete data set for the secondary analysis. The DHS sampling is already done before data has been collected for interested users like me. So, there is no real need to do an analysis; however, a posteriori power analysis can be done just to align the existing sample size and the minimum expected requirement. In fact, four key parameters are included in the computation of the sample size e.g., the effect size, the alpha level, the study design/type, and the statistical power. The alpha (α) is set by the researcher. While statistical power is the probability that a given statistical test will detect a real relationship or treatment effect between variables .The effect size represents the magnitude or strength of the relationship between two variables, it can be measured by the ration or difference. For instance, odds ratios (OR) comparing the likelihood of the same occurring event within two separate groups, or Relative risk (RR) also known as risk difference (Sullivan, 2012).

- For the purpose of this study, all women from15 to 49 years old living in a household located in Cote D'Ivoire are considered as potential participants. The following are the assumptions I made:
- Alpha is 0.05
- Confidence level of 95%
- Power level 80%
- The confidence interval of 2.5% (to detect a difference of 25 per 1000 mortality rate 123 per 1000). After entering the parameters listed above, I selected a sample size to estimate the minimum sample size based on the criteria and assumptions made earlier. Both the plot and its numerical display associated with G Power sample size calculation are shown. As seen in Table 3, at 95% confidence level and a CI of 2.5%, I am expected to draw a representative and unbiased estimate with regards to the study effect or outcome (U5M) under investigation by reaching and interviewing a total of 2,184 women (15-49 years) living in randomly selected households in Cote D'Ivoire.

Table 3.

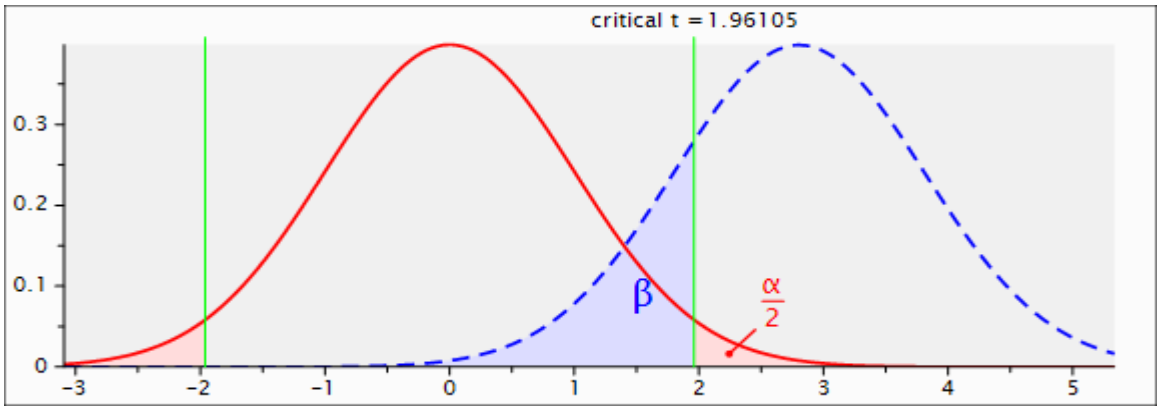
Sample Analysis

Input:	Tail(s)	=	Two
	Effect size d	=	0.12
	α err prob	=	0.05
	Power (1-β err prob)	=	0.8
	Allocation ratio N2/N1	=	1
	=	2.8039971	
	Critical t	=	1.9610518
	Df	=	2182
Output: No centrality parameter	Sample size group 1	=	1092
	Sample size group 2		
	1092		
	Total sample size	=	2184
	Actual power	=	0.8003305

t tests – Means: Difference between two independent means (two groups)

Figure 4

Plot for Sample Analysis through G-power



As shown in Table 3, power (1-β err prob) =0.80, this implies that I decided to get 80 % power to make an inference from these parameters to the population statistics. And power equals one minus beta (type 2 error), this shows the correlation between them and as both beta and power are inversely corrected (Ellis, 2010; Lakens,

2013).

Yet, empirically, the sample size for this study was based on all the available data from 2005 to 2020 merged for a newly pooled database ; however, each survey has been conducted individually; so, there was a sampling for each of these surveys accordingly. All the surveys from 2005-2020 used a stratified two stage cluster design for sampling. All the Cote D'Ivoire DHS surveys were representative at the national level. With regards to the sampling ,for instance, the 2005 surveys used 10 old administrative regions and represent the 19 actual regions constitute with the city of Abidjan .The 11 geographic strata were retained, then these were stratified in urban and rural zones for the sample strata .There was a total of 21 strata in the sampling (National Institute of Statistics, & ICF International, 2005). In the first stage, a sampling random selection was done independently of each stratum. In the second stage, an independent selection was done in each primary unit from the first selection (first stage). Census districts have been systematically and randomly selected from each stratum with proportional probability at the level of census districts as the number of households. In the second stage, a fixed number of households were selected from the regional district (DR) randomly and systematically with equal probability of selection. So, in total, 20 households in each DR have been retained. All members of these households were identified with the household questionnaire for the survey. All women and men aged 15-49 were surveyed via

the individual questionnaire (National Institute of Statistics, & ICF International, 2005).

The 2005 Cote D'Ivoire DHS survey was undertaken between August to October 2005, 4 573 households ,5 183 women and 4 503 men aged 15-49 were successfully interviewed .In detail, a national sample of 4 980 households were selected ,with 20 households for each DR , 249 East/DR were selected at the first stage at the national level. With 109 in urban versus rural 140.The repartition of clusters and households surveyed successfully has been calculated per region and residence. In total the DHS-CI for the 2005 survey had enrolled 247 clusters out of 249 planned for a total of 4 998 households. Among the 4 998 selected households, 4 573 have been identified and 4 368 were effectively and successfully surveyed with 95,5 % response rate (National Institute of Statistics, & ICF International, 2005). Overall, the household survey in DHS 2005, has determined 5 772 eligible women aged 15-49 for the individual survey and 5 183 among them have been successfully surveyed with 90 % response rate (National Institute of Statistics, & ICF International, 2005). In sum, 5183 was the sample size for women 15-49 for the 2005 survey.

With regards to the 2011-2012 survey, a total of 352 clusters were selected for the Cote D'Ivoire DHS 2011-2012 , from this ,about 351 have been surveyed and only one was inaccessible. From these selected clusters, 10,413 households have been selected from this, about 9 873 occupied households were identified during the 2011/12 survey (National Institute of Statistics, & ICF International, 2012). Among the 9873 households, 9 686 have been successfully surveyed (98 % response rate) with a slightly higher rate in

rural areas (99 %) versus (97 %) in urbans areas. Among the 9686 surveyed households, 10 848 women aged 15-49 years have been identified and eligible for individual survey and 10 060 had a successful survey with a 93 % response rate (National Institute of Statistics, & ICF International, 2012). Due to missing variables (hygiene) in the 2005 data, and the fact that expected 2019 data has not been completed, new data is expected soon. Finally this study used merging data for 2011 and 2012.

Fortunately, these numbers, as displayed above, are a relatively huge sample size aligned with the size of the general population and all the protocols used to derive such a large number of participants in the surveys. Using a rigorous sampling strategy is key, yet many types of threats to the study validity (external and internal) may trigger the study accuracy, quality, and generalization. External validity is linked to the sampling size and sample design; hence, to reach a large power level, using a relevant sampling design is essential. This would increase the likelihood to reach a representative sample size which may lead to an accurate inference or estimation of the population parameters (Lakens, 2013). In general, larger sample sizes are best to increase the ability to detect an effect; however, while larger samples are better, sample sizes must be reasonable in size and cost effective (Burkholder, n. d.). The next section discusses the recruitment approach and data collection instrumentation.

Procedures for Recruitment, Participation, and Data Collection

As secondary data analysis, this study used pre existing data: The DHS data to evaluate the strength of the relationship between U5MR and WaSH variables captured in

the merged DHS database. I followed the DHS protocol for data granting and retrieval. More details were provided in sections below about the characteristics of DHS data, ownership, and procedure to retrieve DHS data. I have not done a primary data collection, but if this were the case I would have customized an existing questionnaire from DHS (i.e., DHS household survey questionnaire) including open and closed-ended questionnaires sent by postal mails, oral administration, and /or self-administrated.. Closed-end questionnaires are not only easy to analyze; however, open questions allow more freedom to respondents to express their attitudes, thoughts, and emotions. Administration of the questionnaire via mail could enroll a larger number of the women aged 15- 49 in their home and it is low- price, less time consuming, convenient, with less observation bias (McKenzie et al., 2013). However, this won't be suitable for the target population as many are not literate and do not have a mailing address (Pink, 2013).

Although online surveys have frequently been used in research because I opted for existing data, there is no need for an additional online survey for a primary data collection. Some advantages of online surveys include its low cost and higher speed than most traditional methods of data collection (Ahern, 2005). In addition, online surveys are convenient, easy, and inexpensive, etc. It also encompasses potential multimedia elements such as videos and audio clips (Pew Research Center, 2016). Moreover, the absence of interviewers in online surveys can relatively minimize biases (i.e., interviewer bias and social desirability bias) than the traditional surveys approach (Pew Research Center, 2016). Traditional surveys are more relevant in this case. The reality as related to the socio-demographic characteristics of the priority population is the fact that they live

in rural and are underserved communities mostly, lacking basic natural resources. The majority of them do not have access to the internet (Pink, 2013). Thereby, it will be unsuitable to conduct an online survey for the target community. DHS program used listing of the survey's clusters and individuals through segmentation and stratification approach (ICF International, 2012a; 2012b). This could also minimize certain biases (i.e., observation bias) as well as reach the selected study participants directly in their household (McKenzie et al, 2013). Using a culturally relevant audience-centered survey media to convey the survey questionnaire will more likely optimize the survey and reach the selected population (Schiavo, 2007; Resnick, & Siegel, 2013). DHS program used trained enumerators to administer interviews using standardized questionnaire instruments to eligible individuals previously "selected in a scientifically designed sample" (Measure Evaluation. Org. n.d., p. 59).

Prior to conducting the survey, the measurement tools have been examined and pretested through a pilot study (ICF International, 2012a; 2012b). In fact, a pretest of the questionnaire was also conducted in a few clusters not previously selected for the main survey to assess the instruments (questionnaires) quality and ensure the understanding of the translations by both the respondents and interviewers (ICF International, 2012a). In addition, an Institutional Review Board (IRBs) were submitted, granted after review in addition to ensuring all potential legal issues associated with the research (waiver of liability or informed consent). These documents were given to the study participants, were agreed upon, and signed (ICF

International, 2012a). The following section provides ample details about the measurement tool.

Instrumentation and Operationalization of Constructs

It is important to develop or borrow the most relevant measurement instrument with high reliability and validity to assess the variables under investigation to make unbiased inferences evidenced by the research. To examine the relationship between access to WaSH variables and their influence on U5MR; I used the Cote D'Ivoire DHS data containing the full birth histories of the exposed children, WaSH information, and several potential exposure factors expected to be examined. The main advantage of DHS data is the fact that it enables to look at child mortality and many other factors associated with child death e.g., socioeconomic, demographic variables, and other comorbidities (Fink et al., 2011).The DHS is a nationally representative household survey mainly funded by the United States Agency for International Development and implemented by Macro International in collaboration with national statistical agencies (Fink et al., 2011; ICF International , 2012 b). The standard DHS surveys have large sample sizes (between 5,000 and 30,000 households) and are routinely undertaken every five years to enable comparisons over time.

For this study, the household questionnaire was used and information about WaSH variables and other confounding variables were measured .The birth history contains information on child death, date of birth, gender, child survival status (alive or died), and child age at death. The DHS is an ongoing surveillance and monitoring system

to collect information in the household every five years across countries worldwide (Demographic and Health Survey, 2018). “The data collection methodology consists of trained enumerators administering interviews using standardized questionnaire instruments to eligible individuals selected in a scientifically designed sample” (Measure Evaluation. Org. n.d., p. 59). In the section below, I discussed the reliability and validity of the measurement instrument.

Validity and Reliability of the Measurement Tool

Data quality of a survey directly influences the reliability of the estimates produced. Investigators should ensure that the instrument truly measures what it intended to measure. Using a valid instrument increases the likelihood that assessors would accurately assess what is supposed to be measured. McKenzie et al. (2013) suggested the following approach to ensure the measurement instrument validity e.g.,” face validity (in observation), content validity, criterion-related validity, sensitivity and specificity, and construct validity among others” (p.119). The authors emphasized that the instrument validity can be affected by differences across individuals, therefore using an inter-rater agreement (or observer agreement) must be considered and it is critical to reach a high level of agreement). Moreover, validity can be more informally established in the form of face validity consisting of asking a panel of experts whether the questions really measure the intended concept. The agreement of those experts would determine face validity establishment (Issel, 2009).The DHS program has taken precautionary approach prior to

data collection ; particularly, during pilot and pretesting stage to assess the quality of the questionnaires (measurement instruments) (ICF International, 2012a; 2012b).

With regards to the instrument reliability it represents to the consistency of the measurement process .Windsor et al (2004) defined reliability as an" empirical estimate of the extent to which an instrument produces the same result (measure or score), applied once or two or more times "(Overstated by McKenzie et al., 2013, p.118).Viewed as an internal consistency, reliability would represent the inter-correlations among the individual items on the instrument, e.g., are the instrument items are measuring the same research domain? This is possible by examining the instrument to ensure that the items reflect what it assumes to be, with the appropriate consistency with regards to the item's level of difficulty (McKenzie et al., 2013). McKenzie et al. (2013) asserted that to reduce threats to the quality of data , a statistical method can be employed to assess the internal consistency for a measurement instrument .One such method often used, is the Cronbach's alpha reliability coefficient to estimate the instrument reliability rate. The correlation coefficient (reliability coefficient) alpha Cronbach with a high level of reliability preferably more than .70 must be computed (University of South Alabama, n. d.) for a good reliability level. In fact, conducting a factorial analysis, the coefficient of reliability can evaluate the instrument reliability level. According to Cronbach (1951) reporting the coefficient alpha, Cronbach has become the most used measure of internal consistency. It is convenient, simple, and can be computed in a multi-item scale administration (McCrae et al., 2011). Nunnally and Bernstein (1994) noted that coefficients often provide a good estimate of reliability as the main source of

measurement error for static constructs is the sampling of content ___ "should be applied to all new measurement methods" (McCrae et al., 2011, Pp. 251-252). In addition to the Cronbach's alpha reliability coefficient, rater reliability and test-retest reliability can be used to control the reliability of the measurement instrument (McKenzie et al., 2013).

As mentioned in the early section, prior to conducting the DHS surveys, to ensure the instrumentation quality, the DHS program has examined and pretested through a pilot study the questionnaires (ICF International, 2012a; 2012b). In fact, a pretest of the questionnaire was conducted in few clusters not previously selected for the main survey to assess the instruments (questionnaires) quality and ensure the understanding of the translations by both the respondents and interviewers (ICF International, 2012 a). Additionally, DHS Program continuously updates their data collection instruments and methodology according to developments in international and national priorities, new technologies, and ways to maximize quality results and efficiency (Measure Evaluation. Org. n. d.).

Data Analysis Plan

Study Variables

As a scholar, one must be able to define not only the variables under investigation but also, their operational definition aligned with the research questions and hypotheses (Creswell, 2009).

Independent Variables (Exposures)

The main predictive factors are:

- Access to improved sanitation sources
- Access to improved water sources
- Adequate Hygiene

Below in a tabular format I described the variables and core questions from the database.

Table 4.

Definition of Sanitation and Core Questions

Sanitation		
Sanitation core questions		
What kind of toilet facility do members of your household usually use?		
Do you share this facility with others who are not members of your household?		
With how many households do you share this facility?		
The last time (Name of Child U5) passed stools, what was done to dispose of the stools?		
MDG Categorization of Households (2)	JMP Disaggregated Categorization of Households	Underlying Questionnaire Responses
Not using improved sanitation	open defecation	No facilities, bush or field, open water bodies (open defecation)
	Unimproved	Flush or pour-flush to elsewhere (that is, not to the piped sewer system, septic tank, or pit latrine)
		Pit latrine without a slab, or open pit Bucket
		Hanging toilet or hanging latrine

	Shared use of a facility otherwise classified as 'improved'	Use of facilities listed below were shared by more than one household
Using improved sanitation	Improved sanitation	Flush or pour-flush to a piped sewer or septic tank or latrine pit
		Ventilated improved pit (VIP) latrine
		Pit latrine with slab
		Composting toilet

Table 5.

Definition of water and core questions

Drinking Water		
Drinking water core questions		
What is the main source of drinking water for members of your household? Where is that water source located? How long does it take to go there, get water, and come back? Who usually goes to this source to collect the water for your household? Do you do anything to the water to make it safer to drink? What do you usually do to make the water safer to drink?		
MDG Categorization of Households (2)	JMP Disaggregated Categorization of Households	Underlying Questionnaire Responses
Not using an improved drinking water source	Collection of water from a surface water source	Surface water (river, dam, lake, pond, stream, canal, irrigation channel)
	"Other unimproved sources"	Unprotected dug well Unprotected spring Cart with small tank or drum Tanker truck (3) Bottled water where other water source is classified as unimproved (4)
	Piped drinking water into dwelling, plot, or yard	Piped water into dwelling, yard, or plot

Table 6.

Definition of Hygiene and Core Questions

Hygiene core question		
Can you please show me where members of your household most often wash their hands? (Observe presence of soap, water)		
Do you have any soap or detergent (or other locally used cleansing agent) in your household for washing hands?		
MDG Categorization of Households (2)	JMP Disaggregated Categorization of Households	Underlying Questionnaire Responses
Using adequate hygiene	Adequate hygiene supplies	Presence of soap and water for handwashing
Not using adequate hygiene	Inadequate hygiene supplies	Absence of soap, water, or both in handwashing process

Water and sanitation quality are coded based on the sanitation scale suggested by the WHO/UNICEF Joint Monitoring Program (JMP) as dichotomous improved or unimproved sanitation and water (Fink et al., 2011).

From the Household data a binary 'Water' variable was created to denote improved (coded 1) and unimproved code 2) sources. Improved water sources (classified as standpipes or public taps, protected springs or rainwater collection, boreholes, or tube wells, protected dug wells, piped water on-premises: Piped household water connection located inside the user's dwelling, plot, or yard).

Sanitation: Following the same rationale, toilet/sanitation will be categorized in different presumed 'quality': 1) poor (no access to any toilet facilities), 2) intermediate (indicates access to improved or basic latrine) and 3) high (indicates access to a flush toilet) (Fink et al., 2011). Given the above I regrouped these categories in only 2

dichotomic levels coded as 1 (improved sanitation facility) and 2 (unimproved sanitation).

Hygiene is grouped following this specification based on its definition from WHO/UNICEF Joint Monitoring Program (JMP). Variable for 'Using adequate hygiene' was based on adequate hygiene supplies, that is, presence of soap and water for handwashing; while not using adequate hygiene implied absence of soap, water, or both in the handwashing process. To construct this variable, all "No" responses to 'Presence of water at hand washing place' were treated at inadequate hygiene, and additionally, if water was present but "No cleansing agent observed", these were also treated as inadequate hygiene. In sum, I created new variables from the definition given and grouped hygiene into 2 dichotomic categories , coded as 1 (adequate hygiene) and 2 (inadequate hygiene).

Hygiene categories

Using adequate hygiene	Adequate hygiene supplies	Presence of soap and water for handwashing
Not using adequate hygiene	Inadequate hygiene supplies	Absence of soap, water, or both in handwashing process

Dependent Variables (Outcome Variable)

Under 5 mortality is the main outcome variable in this study. This is self-explanatory and it is the rate of death among children of the set age range. The outcome variable is dichotomous and coded with child death (1= Death) or Alive (0 =Alive). As the characteristics and coding of the study variables are described, below I discuss the protocol to access the DHS data.

Access to Secondary Data

In this study no data was collected because I used a secondary data, the DHS data. However, I followed the protocol to get access to this data e.g., the IRB approval to access secondary data. Therefore, I emailed, called, and presented the IRB approval documents, along with the Data Use Agreement form to the responsible Agency (DHS program) prior to the retrieval of the data. Once all documents were signed and agreed upon, I got access to the DHS data electronically. As aforementioned, all the information in the data was already cleaned and de-identified so that study participants' names, addresses, and other forms of contact information are available to users.

For the purpose of this study, I examined the effect of water, sanitation, and hygiene on mortality among children under 5 in Côte D'Ivoire. As Smith and Firth (2011) noted, prior to conduct a study, the investigator should make an adequate planning to ensure the following: (1) how to retrieve and store the collected data; (2) how to systematically code both interpretive and descriptive information during data analysis ; and (3) how to develop a scholarly report containing a summary of the study results. Following such steps may help readership to get an insight of the process and a better understanding overall. And this resonates well with Nowell et al. (2017) views, according to the authors, it is essential to clearly explain the process to the readership for instance, how the data have been analyzed and/or what assumptions supported their analysis.

For this study purpose, I specifically examined to (a) what extent improved sanitation sources affect the under 5 mortality among women 15-49 in Côte D'Ivoire; (b) to what extent improved water sources affect the under 5e mortality among women 15-49

in Cote D'Ivoire?; (c) to what extent hygiene affect the under 5 mortality among women 15-49 in Cote D'Ivoire? , and lastly (d) to what extent improved water and sanitation sources, and hygiene affect the under 5 mortality among women 15-49 in Cote D'Ivoire?

The DHS data are routinely captured, entered, cleaned, and coded with their own specifications (Measure Evaluation. Org. n. d.; ICF International, 2012). I then retrieved the pooled data and worked on the variables needed to address my research questions and used the Statistical Program for Social Sciences (SPSS), IBM Corporation, Version 27 for data analysis. SPSS is a software package that provides users with statistical analysis, modeling, predictive, and survey research tools used for advanced research activities. Firstly, I assessed the effect of each WaSH variable on the outcome variable, then I measured the joint effect of the WaSH variables on U5MR. Secondly, I used survival information within five years prior to the interview. I conducted a statistical analysis with descriptive statistics (such as frequencies tables, percentages, and counts) about the potential confounders by the survey year. Then, I computed the mortality rates associated with both variables. In addition, I conducted multivariate analysis such as Cox proportional hazard methods (CPH) which is also a survival analysis indeed. Prior to running these statistics, I tested the proportionality assumption associated with the use of the CPH method. Cox proportional model is effective in determining the hazard ratio related to the under-five survival by controlling multiple covariates and confounders in the model simultaneously (Forthofer et al., 2007). In sum, this analysis answered the research questions aligned with the suggested hypotheses.

Statistical Analysis for Each Research Question/Hypothesis

This research focuses on the association between access WaSH on under-five mortality. A multivariate analysis such as Cox proportional hazard survival analysis was undertaken to examine the strength of the relationship between water, sanitation and hygiene and the survival outcome (in terms of mortality) of the under-five children. To examine the effect of the combined water and sanitation sources and hygiene on the mortality among children below five, I conducted a multivariable analysis using Cox proportional hazard regression model as a survival analysis. Not only each individual variable was measured separately; but also, their cumulative effect was examined simultaneously using this multivariate approach. Below, I provided the way I examined the effect of the study variables and the outcome of interest. For the multivariable model, a staged modeling technique was used, for instance, in the first stage, all the demographic, socioeconomic, and maternal variables were entered into the baseline multivariable model to assess their relationship with the study outcome (Mortality). A stepwise backwards elimination process was conducted, and all variables significantly associated with the study outcome variable at a 5% significance level were retained in the model (*model 1*).

Research Question1(RQ1): To what extent does access to improved sanitation facilities affect the under 5 mortalities among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables.

The null hypothesis (H01): There is no statistically significant difference in the under 5 mortalities while controlling for demographic, socioeconomic, and maternal

variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

The alternative hypothesis (HA1): There is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

In this scenario, Cox proportional hazard regression model was conducted, and sanitation facilities were independently examined with the socioeconomic ,demographic, and maternal variables that were significantly associated with mortality, and those variables with p-values < 0.05 will be retained (*model 2*).

Research Question 2 (RQ2): To what extent does access to improved water sources affect the under 5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H02):There is no statistically significant difference in the under 5e mortality while controlling for the demographic ,socioeconomic ,and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

The alternative hypothesis (HA2): There is a statistically significant difference in the under 5 mortality while controlling for the demographic ,socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without .

With regards to RQ2 also Cox proportional hazard regression model was used, and water sources was independently examined with the socioeconomic, demographic, and maternal variables that were significantly associated with mortality. As earlier, those variables with *p*-values <0.05 will be retained (*model 3*).

Research Question 3(RQ3):To what extent does adequate hygiene affect the under 5e mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables ?

The null hypothesis (H03): There is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

The alternative hypothesis (HA3): There is a statistically significant difference in the under 5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

In the RQ3, Cox proportional hazard regression model was used with a similar procedure above , so hygiene was independently examined with the socioeconomic , demographic, and maternal variables that were significantly associated with the mortality outcomes. As before, those variables with *p*-values <0.05 will be retained (*model 4*).

Research Question 4 (RQ4): To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under 5 mortality among

women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H04): There is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

The alternative hypothesis (HA4): There is a statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

Similarly, to the research questions above, for RQ4 also, I conducted cox proportional hazard regression models. In the last stage (model 5) all three independent variables (water , sanitation, and hygiene) were simultaneously examined with all the variables entered into model 1, and those variables with *p*-values <0.05 will be retained in the final *model (model 5).*

The estimates in the Cox proportional hazard model are the hazard ratios (HR) and their 95% confidence intervals obtained from the adjusted Cox proportional hazard models was used to assess the simultaneous effect of water sources, sanitation sources, and hygiene on the under 5 mortalities. It automatically controlled for all confounding and interacting variables into the model that also affect the outcome variable of this study. Prior to running these statistics, I assessed the proportionality assumption associated with the use of the CPH method. Cox proportional model was effective in

determining the hazard ratio related to the under-five survival by controlling multiple covariates and/or confounders in the model simultaneously (Forthofer et al., 2007). In sum, this analysis answered the research questions aligned with the suggested hypotheses.

Cox proportionality is also known as a semi-parametric method. According to Sullivan (2012), in CPH hazards ratio is the measure of effect and represents the risk or probability of suffering the event of interest, "conditional on the fact that the participant has survived up to a specific time" (p. 260). Cox proportional hazard (CPH) method provides the value of the Hazard Ratio which is a proxy for the Odds ratio (in the logistic regression model) (Forthofer et al., 2007). CPH models can also distinguish individual contributions of covariates on survival. CPH model is an appealing analytic approach because it is both flexible and powerful (Spruance et al., 2004). Moreover, using SPSS, I did an adjustment of the cluster sampling and estimated standard errors. As mentioned in the section above, I conducted correction tests to minimize information bias. Furthermore, comparing the unadjusted HR and the adjusted HR can help to assess the magnitude of potential effect modification (or an interaction effect) and report them.

Strengths and Limits

The study method is an observational quantitative design, also known as correlational. Most particularly, cross-sectional analytical design to examine multiple factors including WaSH variables on U5MR. As the relationship is only correlational, no causal link can be determined in such designs (Frankfort-Nachmias, Nachmias, &

DeWaard, 2015). This design is relatively quick and easy to conduct, data on all variables are collected once. One of the strengths of this design is the fact that it provides a snapshot of events or disease frequency and distribution at a given point in time, unlike experimental designs where causality can be assessed through experiment (by comparing control and experimental groups), this is impossible in observational studies such as cross-sectional designs (Forthofer et al., 2007). Another strength of cross-sectional studies is that the study participants do not need to follow any experimental protocol with exposure to an intervention that can be ethically challenging (Mann, 2012).

Additionally, in cross-sectional design studies, there is no need to form groups in control versus experimental groups. Hence, the same data source is generally sufficient to make inferences and assess the relationship between the study variables that may yield many possible outcomes as well. Cross-sectional is associated with a single data collection point, relatively inexpensive yet can be a source of possible spurious associations between the study variables. The cross-sectional design is also useful to provide evidence-based information for decision making, planning, and resource allocation for prevention and healthcare (Health Knowledge, n. d.). Moreover, using this design, a large sample size can be drawn (i.e., the DHS household surveys are between 5,000 and 30,000), leading to a higher external validity and power for the study results (Forthofer et al., 2007; Frankfort-Nachmias et al., 2008).

Using multi-stage cluster sampling methodology is cost-effective, less time consuming, and appropriate with sampling frames readily available at the level of the cluster. This design is relevant for institutional surveys (Johns Hopkins Bloomberg

School of Public Health, 2009). With regards to the strength of the instrumentation, the DHS questionnaires have a high level of reliability, the surveys have large sample sizes (between 5,000 and 30,000 households) and are routinely undertaken every 5 years to allow comparisons over time (ICF International, 2012b). One great strength of DHS data is that multiple factors can be examined with child mortality. However, secondary data with the cross-sectional design is not suitable to ascertain a cause-and-effect relationship between variables under study (Frankfort-Nachmias et al., 2008; Szklo et al., 2014).

With regards to the DHS data, Asaolu et al. (2016) noted that the cross-sectional drawn from DHS has some limitations including recall bias led by inaccurate reporting of event timing or the level of underreporting. One strength of the data analysis approach is the use of the CPH method, a powerful and flexible (Spruance et al., 2004) method to simultaneously control multiple covariates and confounders in the model (Forthofer et al., 2007). In addition, through SPSS I can make the necessary adjustments to cluster sampling and measure standard errors. Another strength is the restriction of the analysis to the most recent births within 5 years prior to each survey to minimize potential recall bias on death and birth dates reported in the survey data. Additionally, appropriate adjustments for sampling design, sampling weight, and the high response rate (about 95%) to the survey are key strengths for the DHS data (Ezeh et al., 2014). Despite countless advantages of the design, the methodology, and the measurement tool; the risk of spuriousness led by random errors, bias, confounding, and the interaction effect may still trigger the study validity and reliability. Thereby, interested researchers using this data must effectively assess, control, and report these issues.

Threats to Validity

McKenzie et al. (2013) suggested that "it is of vital importance that planners and evaluators make sure that the data they collect are accurate, reliable, valid, fair and unbiased" (p.117). Similarly, Issel (2009) emphasized that because threat to data quality is present regardless of how effective data has been collected; therefore, it is essential to minimize them to improve data quality. The quality (validity and reliability) of the measurement instrument is also essential, a poor instrumentation would more likely trigger the quality of the data gained from that instrument. As aforementioned in the early section, prior to conducting the DHS surveys, to ensure the instrumentation quality, the DHS program has examined and pretested the measurement tool through a pilot study (ICF International, 2012a; 2012b). In fact, a pretest of the questionnaire was conducted in few clusters not previously selected for the main survey to assess the instruments (questionnaires) quality and ensure the understanding of the translations by both the respondents and interviewers (ICF International, 2012 a). Additionally, Issel (2009) asserted that during the collection of data "the observation should be as unobtrusive as possible" (p.123) and ensuring that sensitive information be held confidentially and anonymously (McKenzie et al., 2013). Fortunately, these ethical protocols have been followed by the DHS program during data collection as amply discussed earlier in the data collection section (ICF International, 2012a, Measure Evaluation. Org. n. d.). The

following are potential elements (i.e., biases, confounders, and interactions effect) that may trigger data quality.

Selection Biases

The representativeness and generalization of the research findings are related to how well the target population was sampled. Thus, it is important to ensure an effective sample design and an adequate sample size aligned with the research question and objectives (Frankfort-Nachmias et al., 2008; Forthofer et al., 2007). Selection bias occurs when selecting study participants or their likelihood of being retained in the study induces different results if the entire target population were considered (Boston University School of Public Health, n. d.). When the sampling is non-representative of the exposure-outcome distributions in the overall population, this will distort (selection bias) the measures of association (Boston University School of Public Health, n. d.). Szklo et al. (2014) defines selection bias as a systematic error while conducting or designing a study and it is induced by flaws either in the selection method used for study participants or in the procedures to collect exposure and /or disease data: consequently," the observed study results will tend to be different from the true results" (p. 100). This bias tends to influence the probabilities of inclusion of the study participants in the study sample based upon relevant study characteristics e.g., the outcome and exposure (Szklo et al., 2014). Not addressing these biases may lead to a distortion of the study validity and power by extrapolating (or overestimating) or underestimating the true strength of the association between predictors and dependent variables (Frankfort-Nachmias et al, 2008).

Not addressing this will finally bias point estimates and standard errors leading to incorrect inferences (Bell et al., 2012). Bell and colleague's perspective clearly elucidated the importance of weighting using this descriptive argument while all these elements cited above must be considered with complex surveys data to minimize bias(s) that may arise from differences in designs, sampling methods, and the measurement approach used for these data collections.

In fact, selection bias can occur in my study both at the design stage, if the adequate sampling design and sample size associated with research questions and objectives were done ineffectively. Because I am already aware of potential biases, I carefully examined the study design and conducted the study to minimize any internal and external validity concerns including selection bias and other biases.

Strategies to Minimize Selection Bias in his Study

According to Szklo et al. (2014), quality control and quality assurance are essential to minimize bias and some specific ways to address this bias include ensuring a detailed protocol design and developing appropriate data collection tools and procedures. Moreover, training and certifying the field staff, doing a pilot study, and pre-testing before full implementation (Szklo & Nieto, 2014) are important steps to minimize selection bias at the early stage. Thus, I did a priori sample size calculation based on the study design and all the parameters needed for this computation. Because my study is a secondary data analysis, it implies that the data has been previously collected by the DHS Agency with a specific sampling design, data collection tool, and strategies. The DHS

data used a probability sampling to select the study population. This sampling method provides the statistical basis of the representativeness of the sample drawn from the target population. A probability sampling assumes that everyone (from the target population) will have the same likelihood for selection. The randomness of this design will increase the representativeness of the survey population (McKenzie, Neiger, & Thackeray, 2013). While a non-probability sampling cannot achieve randomness (Issel, 2009), the assumption is that the data collectors have considered that there is a minimal or no difference between participants in the program and those who are not. Fortunately, the DHS data has a huge size which may more likely increase the external validity of this study. Another way to minimize selection bias is before data collection which is not applied in the current scenario because data is previously collected) prior to the sampling at the design stage could be matching and sensitivity analysis (Ha et al., 2016). For instance, matching socio-demographics and economic characteristics of the potential study participants can help to minimize selection bias.

Another approach to address selection bias is using weighting adjustments. For instance, weighting can compensate for biased estimators induced by survey nonresponse (Pike, 2008). Weighting can help to determine sub-groups in the sample observation of the collected data as well as assess variations and characteristics of these subgroups in the collated data. Using weighing can correct survey data addressing potential biases that may arise without adjustment. Large nationally representative health surveys data differ from simple random sampling surveys in four elements (Bell, Onwuegbuzie, Ferron, Jiao, Hibbard, & Kromrey, 2012):

- The unequal probabilities of selection and oversampling of certain populations subgroups generally use sample design in surveys to ensure accurate precision of parameters estimated.
- "Multistage sampling results in clustered observations (where variance among units within each cluster is less than the variance among units in general)" (p.3).
- The issue with sampling stratification, although it may ensure adequate representative sampling pertaining to the stratified variable(s), this may also lead to inaccurate estimates of the variance.
- And lastly, the nonresponse unit and other poststratification corrections or adjustments are employed to the sample to allow unbiased estimates (Bell et al., 2012).

Information Biases

There are two main types of biases: Selection bias and information bias (Szklo et al., 2014). Information bias in an epidemiologic study is induced by either imperfect definition of the study variables or flawed data collection procedures. These errors may lead to misclassification of exposure, or an outcome status for a substantial proportion of participants (Szklo et al., 2014). There are differential and non- differential misclassification. In general, misclassification comes from 1) incomplete medical records, 2) errors in recording, 3) records misinterpretation or errors in records, e.g., incomplete filling of questionnaires or incorrect disease codes (Statistics How To, 2017).

Given the above and because data was already collected (secondary data), I think my research may have several types of informational bias. For instance, information bias due to incorrect completion of the household questionnaires, sensitive questions may have triggered reluctance to correctly give the correct response to these sensitive questions. In addition, recall bias may have occurred due to a long time between interviews (as these DHS surveys are conducted every 5 years). Lastly, respondents may have faced challenges to provide accurate information due to memory gaps about the under 5 birth history and parental financial status.

Moreover, there might be differential misclassification between groups, those with more advantageous socioeconomic status have more access to better conditions (water, sanitation facilities, and hygiene) as compared to counterparts with lower SES. This context may lead to differential exposure bias; subsequently, a differential outcome as the combined effect of the exposure (i.e., better sanitation, better water facilities, and hygiene) as well. In addition, some errors in records can lead to informational bias. Furthermore, observer bias due to the presence of the interviewer during the interview, depending on the level of social desirability needed of the respondents. Lastly, non-response may have occurred as well.

Other challenges associated with reliable and correct data collection for the DHS surveys may be the lack of comfort of respondents to disclose sensitive information. How perceived confidential and anonymous questions were handled or asked? This could also increase social desirability bias and recall bias in addition to the choice of respondents (in general, the head of the household responds to the questionnaire). However, it is not

evident that the head always has accurate information related to the family assets. So, it is essential to select the respondents based on their level of knowledge of the household source of finance.

In the DHS data, the measurement of socioeconomic position (SEP) and the adequate data collection instruments—differ significantly between low- and high-income nations (Howe et al., 2012). Unfortunately, DHS data do not have economic parameters (i.e., income or consumption expenditure); therefore, assets, housing characteristics, and access to basic sources (i.e., sanitation, drinking water, and electricity) are used as a proxy (Howe et al., 2012).

Strategies to Minimize Information Bias

Ideally, it is more effective to assess and minimize information bias through various approaches (i.e., during the design and data analysis stage). These include data quality control and relevant statistical analysis. Quality assurance before data collection is related to standardizing procedures and can prevent or at least minimize" systematic or random errors in collecting and analyzing data" (Szklo et al., 2014, p. 313). In contrast, quality control is done after data collection and is fundamental as a remedial action aimed at minimizing bias and reliability problems (Szklo et al., 2014). In the current study, because the data was already collected through DHS household surveys, the quality assurance was seemingly done prior to data collection. Szklo et al. suggested that kappa statistics at the analysis stage be used to explore the likelihood of differential exposure

misclassification bias, and the Bland-Altman plot for concise summary measures optionally to minimize the bias.

Confounding Variables

The most effective approach to minimize spurious factors including confounders, it is critical to carefully do a study plan, design, and beyond; as well as the use of statistical analysis and stratification, thereafter to control the remaining confounders (Sullivan, 2012). Unless some of the variables cannot be controlled e.g., residual confounders, however, with large sample size and randomization such issues could be minimized in general.

Confounding variables: Household wealth index, spouse/paternal level of education, place of residence , maternal education , mother work status, number of residents in the household over the age of five, father work status, presence of child health card with the mother, number of household members, place of residence, religion, matrimonial status, regions of residence, gender of woman's child, mother age at childbirth. The assets followed the DHS data e.g., car, phone, radio, fridge, type of floor material used in rooms, television, electricity, bicycle, and motorcycle. In this questionnaire, the household wealth index was grouped as richer, poorer, richest, middle, and poorest. For more convenient analysis, I re-categorized the household wealth index into) 1) poorest households and2) Non poor households. Table 7 is a sample of the type of numerical descriptive statistical analysis conducted. Lastly, the level of U5MR was

assessed as the outcome variable, while controlling for confounding and interaction effects simultaneously.

Table 7.

Mother Caregivers Socio-demographic Characteristics of the Children less than Five years

Variables Definition	Categorization/groups	Frequency	Percent
Age (years)	≤29		
	≥ 30		
Gender of woman's child	Male		
	Female		
Presence of child	Yes/No		
health card with the mother	Poor		
	Middle		
	Rich		
Matrimonial Status	Single		
	Married		
	Divorced/separated/widow/		
	Polygamous		
	Monogamous		
	Single parenthood		
Religion	Christianity		
	Islam		
	Traditional		
	Others		
Regions of Residence			
Place of Residence	Centre		
	Centre East		
	Centre North		
	Centre West		
	North		
	Northeast		
	Northwest		
	West		
	South		

	Southwest
	City of Abidjan
	Rural
	Urban
Number of under-five children caring for	1 under 5 child
	≥ 2 under 5 children
Number of household members	≤ 4
	≥ 5
Number of bedrooms occupied	≤ 3
	≥ 4
	No Formal
Maternal level of education	Primary
	Secondary
	Tertiary
	Others
	No Formal
Spouse/ paternal level of education	Primary
	Secondary
	Tertiary
	Others
	1. poor households
Household wealth Index	2. middle households
	3. rich households
	Business/Commerce
Respondents' occupation	Civil Service
	semi -skilled
	Others

Controlling Confounding Variables

DHS data is a secondary source of data so I do not have control of the confounding variables at the designing stage because the study was already designed and data was already gathered, so spurious factors e.g., effect modifiers and confounders

could be addressed through statistical analysis. The estimates in the Cox proportional hazard model are the hazard ratios (HR) and their 95% confidence intervals obtained from the adjusted Cox proportional hazard models was used to assess the effect of the combined effect of water sources, sanitation sources, and hygiene on the U5M. Cox proportional regression automatically controlled for all confounding and interacting variables into the model that also affect the outcome variable of this study. This section is related to the statistical analysis plan and methods, including descriptive statistics (such as frequencies) about the potential confounders, then the computation of the mortality rates associated with both variables (i.e., water sources, sanitation facilities, and hygiene). In the analysis stage, I used multiple variates method to evaluate WaSH variables and their influence on U5MR using survival analysis such as Cox proportional hazard method (Ezeh et al., 2014).The key interesting fact using Cox proportional model is its powerful capability to determine the hazard ratio associated with the under 5 survival while controlling multiple covariates and/or confounders in the model simultaneously (Forthofer et al., 2007). Conclusively, observational research is susceptible to chance, bias, and confounding effects, therefore, these elements must be taken into consideration at the design and analysis stages to minimize their distortion in the study results (Health Knowledge, 2011).

Statistical Limitations

Even though this study might have a great deal of external validity (mainly due to the huge sample size) and power, limitations inherent to the study design must be considered. One of the main limitations is the fact that causality cannot be ascertained in

a cross-sectional design, because no temporal relationship between exposure (water, sanitation, and hygiene) and outcome (under 5 mortality) can be inferred from this analysis. Often cross-sectional studies estimate prevalent rather than incident cases; yet the data will always reflect determinants of survival as well as etiology (Health Knowledge, n. d.).

Social Change Implications

Practical Contributions of this Study for Public Health and Epidemiology

In public health, programmatic, advocacy, and health policy perspective, the assessment of the impact of water and sanitation program will provide tangible and substantial evidence to inform decision making for planning and prevention through designing effective upstream population-based strategies to mitigate or minimize the problem vulnerable individuals face in Cote D'Ivoire and elsewhere. Evidence-based data from this study can also guide program planners, public health practitioners, researchers, and funders for effective decision making. In addition, this study could serve to guide and advocate more resources for the program and help the affected community in Cote D'Ivoire and beyond. Lastly, from an epidemiological standpoint, the examination of multiple risk factors associated with child mortality in this cross-sectional study could provide more insight into the multifactorial determinants of child mortality. As well as to guide for prioritization and prevention measures for the population at risk to empower them e.g., improve well -being, reduce related morbidity and mortality of the target population.

The potential social change implication includes the use of health education and promotion to sensitize the local community to adopt preventive behaviors (i.e., proper hygiene attitude; provide education programs; promote availability and access to clean water; and proper sanitation facilities). As aforementioned, all this would gradually impact the community well-being, quality of life, and life expectancy. In a programmatic standpoint, insights from this study may guide and frame prospective program planning, prevention, advocacy, and resources allocation (Parker, & Thorson, 2009; Resnick et al., 2013).

Ethical Procedures

Like traditional biomedical research, compliance with the ethics guidelines using de-identified data not only can provide benefits, but also, minimize issues with privacy, confidentiality, and risks. In this research study, I used DHS data to examine the strength of the association between child survival and access to WaSH variables. First, I followed the DHS protocol for data granting and retrieval from the appropriate Agency. DHS data is a nationally representative household survey mainly funded by "the United States Agency for International Development and implemented by Macro International in collaboration with national statistical agencies (Fink et al., 2011).

I presented the IRB approval documents, along with the Data Use Agreement form, to the Agency prior to retrieval of the data. Once all documents were signed and agreed upon, I was allowed access to the DHS data on September 4th, 2020 (IRB number : 09-04-20-0296262). Before data collection by the DHS Agencies, various ethical

procedures were applied and followed to ensure the privacy, autonomy, and confidentiality of the respondents (ICF International, 2012a, Measure Evaluation. Org. n. d.). Confidentiality is a major concern for DHS, in fact, the DHS surveys are anonymous surveys which do not allow any potential identification of any single individual or household in the data file. Confidentiality is also a key factor influencing response rate to sensitive questions pertaining to partners and sexual activity. For instance, in surveys that include HIV testing DHS policy requires that household codes and PSU be scrambled in the final data to further anonymize the data and destroy the original sample list (ICF International, 2012a).

Furthermore, the household questionnaire in the DHS survey starts with an introductive message explaining the "Informed consent" and the objective of the interview before agreement and signing. In addition, the questionnaires were filled confidentially and anonymously with the incorporation of the final deidentified and aggregated data to comply with ethical protocols (ICF International, 2012a) including confidentiality, anonymity, privacy, and respect of human subjects used as study participants. This resonates well with Rothstein (2015) assertion that loss of privacy may lead to both intangible and tangible harms. Careful consideration of legal and ethical issues is key while doing research with humans' participants. Doing so could facilitate effective implementation, planning, and enhancement of various public health programs and research activities.

Summary

The under 5 mortalities have declined to 39 -50 percent per 1,000 live births (UN IGME & UN MMEIG, 2019). Despite remarkable progress in child survival overall, huge disparities still appear between regions. Sub-Saharan Africa (SSA) still lag behind expectations (UN IGME & UN MMEIG, 2019). The lack of or limited WaSH quality and access expose millions of children to morbidities associated with WaSH and subsequently leading to preventable death. About 800 million of children die daily from diarrhea and other illnesses mainly led by lack and/or improper sanitation and water sources (UNICEF Côte D'Ivoire, n. d). Understanding how WaSH influences childhood health (i.e., U5MR) are critical to minimize its burden; hence, reducing case-specific morbidity and mortality among these children. This study seeks to better understand the risk exposure faced by children below five in Cote D'Ivoire and its linkage to the high U5MR. The overall goal of this study was to specifically explore the magnitude of the relationship between access to improved WaSH and mortality in children less than 5 among women 15-49 years old in Cote D'Ivoire, using all available and relevant Cote D'Ivoire DHS data from 2005-2020. This study expects to contribute to child survival literature by examining how WaSH affects children's mortality. In this research study, I expect to provide an insight into the current strength of the association between U5MR and access to water, sanitation, and hygiene using pooled Cote D'Ivoire DHS data.

The section above described the study design and rationale; the research methodology; the study population; the setting; the recruitment strategy; power analysis and sample size; the sampling method; the data collection tools; definition of the study

variables; the DHS data and protocol to access; and statistical analysis plan. Moreover, chapter 3 introduced and addressed potential threats to the study validity and provided a thorough explanation of related ethical procedures. In Chapter 4, I present the results of the study.

Chapter 4: Results

The purpose of this study was to examine the magnitude of the association between access to WaSH variables and the under 5 mortality rates among women 15-49 in Cote D'Ivoire. This research tried to uncover the extent to which WaSH affects mortality in this age group. I design the following research questions and related hypotheses to guide this research:

Research Questions and Hypotheses

RQ1: To what extent does access to improved sanitation facilities affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$1: There is no statistically significant difference in the under-5 mortality while controlling for demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

H_A1: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

RQ2: To what extent does access to improved water sources affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$2: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

H_A2: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

RQ3: To what extent does adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$3: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

H_A3: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

RQ4: To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under-5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

$H_0$4: There is no statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among

women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

H_A4: There is a statistically significant difference in the under-5 mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

Data Collection

My research proposal was approved by Walden University IRB (09-04-20-0296262), and the protocol for data access was granted on September 4th, 2020. I therefore retrieved the DHS datasets and did not find any major discrepancy in the plan I suggested earlier on Chapter 3. I conducted data quality for completeness, accuracy, and consistency of the data set so that I could address missing data issues in the data set. To examine the relationship between access to WaSH variables on U5MR, I used the Cote D'Ivoire DHS data containing the full birth histories of the exposed children, WaSH information, and several potential exposure factors expected to be examined.

For this study, I used the household questionnaire and information about WaSH variables and other confounding variables were examined and measured. The birth history contains information on child death, date of birth, gender, child survival status (alive or dead), and child age at death. The DHS is an ongoing surveillance and monitoring system to collect information in the household every 5 years across countries worldwide (Demographic and Health Survey, 2018). The methodology used for data collection involves trained enumerators conducting interviews using standardized

questionnaire instruments to eligible participants selected through a scientific sampling design (Measure Evaluation.org., n.d., p. 59).

In this study, women aged between 15 to 49 years, with children under the age of 5 who are dead or alive, were the target population. The data used for this study were from the children's module, woman's module, and household module. As Fink et al. (2011) noted, one of the main advantages of DHS data is the fact that it enables investigators to look at child mortality and many other factors associated with child mortality including socioeconomic factors, demographic characteristics, and other comorbidities.

Descriptive Statistics

As Trochim (2006) noted, descriptive statistics explain simple characteristics of quantitative data including variances, average, and sum (Frankfort-Nachmias & Leon-Guerrero, 2015). I conducted descriptive statistics such as counts, frequencies, and percentages for the independent WaSH variables. I also conducted descriptive statistics on selected demographic, socio- economic, and maternal characteristics of the target population. Table 8 below shows the characteristics of children and their mothers enrolled in the study. A total of 7,776 children under 5 years old were enrolled in this study. The majority (53.6%) of them were 12-59 months old, followed by the 0-28 days (24.6%) neonatal, and 1-11 months/post-neonatal (21.8%). The vast majority (83%) had a birth card, and 70.8% received mother breast milk for at least 6 months. Most (58.2%) of the mothers enrolled were young and under 30 years old. More than half (67.7%) of the

mothers did not have a formal education, and the majority of them (85.5) were living with a male partner.

Table 8.

Characteristics of Children and Mothers Enrolled in the Study (N=7,776)

Characteristics	Frequency % (N=7,776)
Gender of child	
Female	49.5% (3852)
Male	50.5% (3924)
Child age group	
0-59 months	91.2% (7093)
0–28 days/neonatal	24.6% (1910)
1-11 months/post-neonatal	21.8% (1695)
12–59 months/child	53.6% (4171)
Single birth	95.4% (7417)
Multiple births	4.6% (359)
Child has a birth card	83% (6420)
Child has no birth card	17% (1317)
Currently breastfeeding	33.8% (2597)
Not breastfeeding	66.2% (5091)
Breastfeeding >=6 months	70.8% (1838)
Breastfeeding <6 months	29.2% (759)
Weight at birth/recall	
Not weighted	38.1% (2962)
From written card	39.3% (3056)
From mother`s recall	17.9% (1391)
Don`t know	0.6% (43)
Special answers	4.2% (324)
Birthweight average or larger	85.6% (3807)
Small or very small birth weight	14.4% (640)
Mother > 29 years	41.8% (3247)
Mother ≤29 years	58.2% (4529)
Mother education status	
Some education	32.3% (2515)
No education	67.7% (5261)
Mother employment status	
Working	71.6% (5565)

Not working	28.4% (2211)
Mother husband or partner status	
With a partner	85.5% (6648)
Without a partner	14.5% (1128)
Husband/partner education status	
Husband/partner education status	
Some education	34.5% (2686)
No education	62.3% (4842)
Missing information	3.2% (248)
Number of under 5 cared for	
2 or more under 5	67.4% (5242)
0 or 1 under 5 children	32.6% (2534)
Mother religion	
Muslim	45.7% (3548)
Catholic	16.1% (1245)
Methodist	1.9% (147)
Evangelical	15.2% (1182)
Other Christian	3.7% (290)
Animist	3.9% (300)
No religion	12.4% (965)
Other	1% (79)

Type of Water Sanitation Available in Households Where Children Lived

Table 9 describes the type of water sanitation available in households where children lived. Less than a third (19.8%) of surveyed households had access to piped water at home. Only 18.2% of the children lived in a household with flush toilets of different categories. More than a third (34.4%) of these household members did not have access to toilets in their households. About 47.4% of the households had water and handwashing items present at the time of the survey.

Table 9.

Water and Sanitation Available in Households Where Children Lived

Characteristics	Household (N=9,679)	
	%	N
Source of drinking water		
Piped into dwelling	10.0%	923
Piped to yard/plot	20.0%	1,957
Public tap/standpipe	17.0%	1,616
Tube well or borehole	15.0%	1,443
Protected well	17.0%	1,661
Unprotected well	12.0%	1,202
Protected spring	0.5%	47
Unprotected spring	3.0%	256
River/dam/lake/ponds/stream/canal/ irrigation channel	5.0%	461
Tanker truck	0.0%	2
Cart with small tank	0.0%	3
Bottled water	0.0%	29
Other	1.0%	79
Type of toilet facility in household		
Flush to piped sewer system	5.1%	490
Flush to septic tank	10.2%	989
Flush to pit latrine	2.8%	271
Flush to somewhere else	0.1%	10
Flush, don't know where	0.0%	4
Ventilated Improved Pit latrine (VIP)	0.4%	38
Pit latrine with slab	26.9%	2,600
Pit latrine without slab/open pit	19.7%	1,905
Other type of toilets	0.3%	27
No facility/bush/field	34.4%	3,330
Water and handwashing items present	47.4%	4,585

I created “mortality age groups” as follows: 0-28 days (neo-natal), 1-11 months (post neonatal), and 12-59 months (child). Table 10 describes the characteristics of the children alive and those who died before reaching 5 years. The vast majority of the

children were alive (91.2%; 7,093/7,776). Among the children alive, 50.6% were female, and among the 683 children who died, 61.6% were male. Out of the children alive, 57.3% (4,061/7,093) were in the age group 12-59 months. The vast majority of the women/mothers didn't receive formal education, other characteristics are detailed in Table 10.

Table 10.

Characteristics of Under-5 Status (Alive or Dead) by Demographic and Maternal Factors

Characteristics	Child status		
	Child alive (N=7093)	Child died (N=683)	Total (N=7776)
	% (n)	Proportion	Proportion
Female	50.6% (3590)	38.4% (262)	49.5% (3852)
Male	49.4% (3503)	61.6% (421)	50.5% (3924)
0–28 days/ neonatal	22.8% (1615)	43.2% (295)	24.6% (1910)
1-11 months/ post-neonatal	20% (1417)	40.7% (278)	21.8% (1695)
12–59 months/ child	57.3% (4061)	16.1% (110)	53.6% (4171)
Working	71% (5036)	77.5% (529)	71.6% (5565)
Not working	29% (2057)	22.5% (154)	28.4% (2211)
Husband/partner education status			
Some education	36% (2472)	32.5% (214)	35.7% (2686)
No education	64% (4398)	67.5% (444)	64.3% (4842)
Some education	32.8% (2324)	28% (191)	32.3% (2515)
No education	67.2% (4769)	72% (492)	67.7% (5261)
Mother husband or partner status			
With a partner	85.4% (6058)	86.4% (590)	85.5% (6648)
Without a partner	14.6% (1035)	13.6% (93)	14.5% (1128)

Mother > 29 years	41.3% (2932)	46.1% (315)	41.8% (3247)
Mother ≤29 years	58.7% (4161)	53.9% (368)	58.2% (4529)
Religion			
Muslim	45.5% (3219)	48.2% (320)	45.7% (3548)
Catholic	16.2% (1143)	14.9% (102)	16.1% (1245)
Methodist	2% (138)	1.3% (9)	1.9% (147)
Evangelical	15.4% (1089)	13.6% (93)	15.2% (1182)
Other Christian	3.7% (265)	3.7% (25)	3.7% (290)
Animist	3.8% (270)	4.4% (30)	3.9% (300)
No religion	12.4% (878)	12.7% (87)	12.4% (965)
Other	1% (71)	1.2% (8)	1% (79)
Child has a birth card	91% (6420)	0.00%	83% (6420)
Child has no birth card	9% (634)	100% (683)	17% (1317)
Number of under 5 cared for			
2 or more under 5s	69.4% (4919)	47.3% (323)	67.4% (5242)
1 or 0 under 5 children	30.6% (2174)	52.7% (360)	32.6% (2534)
Currently breastfeeding	36.9% (2597)	0.00%	33.8% (2597)
Not breastfeeding	63.1% (4432)	100% (659/659)	66.2% (5091)
Weight at birth/recall			
Not weighted	37.1% (2635)	47.9% (327)	38.1% (2962)
From written card	41.5% (2942)	16.7% (114)	39.3% (3056)
From mother's recall	17.4% (1234)	23% (157)	17.9% (1391)
Don't know	0.4% (30)	1.9% (13)	0.6% (43)
Special answers	3.6% (252)	10.5% (72)	4.2% (324)
Mother's perceived birth size			
Birth weight average or larger	86.6% (3615)	70.8% (192/271)	85.6% (3807)
Small or very small birth weight	13.4% (561)	29.2% (79/271)	14.4% (640)

The comparisons between child status (alive/dead) and a number of variables were described by type of population and related distribution. These variables were

grouped in three categories: socio-demographic factors, household socio-economic factors, and mother's characteristics (respectively in Tables 11 & 12). For example, Table 11 shows the relationship between socio-demographic factors and under 5 survival versus death. Table 12 shows the household socio-economic distribution and mothers' characteristics with under 5 survival/versus death. The factors significantly associated with child survival included living in a household with improved sanitation facilities, with 2-4 siblings, being a female child, and or living in the Western region of the country (Table 11). In Table 11, the frequency of each variable in relationship with children mortality versus survival is reported.

- Poorest households Nonpoor households (45.2%) versus Poorest 40 percent of households (54.8%)
- Male headed households have a higher under-five mortality (86.2%) versus women Female headed households (13.8%).

Table 11.

Socio Demographic Factors and Under-five Survival Vs Mortality

Characteristics		Child Status								
		Child Alive		Child Died		Total		95.0% CI		p-value
		n=7,093	%	n=683	%	N	%	Lower	Upper	
Female headed households	Male headed household	6059	85.4%	589	86.2%	6648	85.5%	0.78	1.26	0.937
	Female headed household	1034	14.6%	94	13.8%	1128	14.5%	Ref		
Electricity status	Electricity	3355	47.3%	280	41.0%	3635	46.7%	0.64	1.04	0.099
	No electricity	3738	52.7%	403	59.0%	4141	53.3%	Ref		
Radio	Radio owned	4109	57.9%	370	54.2%	4479	57.6%	0.69	0.97	0.023

	No radio	2984	42.1%	313	45.8%	3297	42.4%	Ref		
Television	Television owned	2703	38.1%	228	33.4%	2931	37.7%	0.75	1.22	0.713
	No television	4390	61.9%	455	66.6%	4845	62.3%	Ref		
Refrigerator	Refrigerator owned	653	9.2%	56	8.2%	709	9.1%	0.81	1.53	0.515
	No refrigerator	6440	90.8%	627	91.8%	7067	90.9%	Ref		
Bicycle	Bicycle owned	3677	51.8%	404	59.2%	4081	52.5%	1.10	1.56	0.003
	No bicycle	3416	48.2%	279	40.8%	3695	47.5%	Ref		
Motorcycle or scooter	Motorcycle or scooter owned	2279	32.1%	240	35.1%	2519	32.4%	0.94	1.34	0.194
	No motorcycle or scooter	4814	67.9%	443	64.9%	5257	67.6%	Ref		
Car or truck	Car or truck owned	178	2.5%	13	1.9%	191	2.5%	0.47	1.53	0.586
	No car/truck owned	6915	97.5%	670	98.1%	7585	97.5%	Ref		
Wealth ranking	Nonpoor households	3525	49.7%	309	45.2%	3834	49.3%	0.85	1.38	0.513
	Poorest 40% of households	3568	50.3%	374	54.8%	3942	50.7%	Ref		

Mother's Characteristics and Household Socio-Economic Factors

Significantly higher proportions of children dying are found in the following groups:

- Among mothers with no education (72.0%) versus (28.0%) for those with education.
- Among mothers who are working (77.5%) versus (22.5%) not working.
- Among younger mothers below 29 (53.9%) versus older mothers (46.1%).
- Those who were not weighed (47.9%) , as compared with those from written cards (16.7%); and those from mother`s recall (23.0%).

- During the neonatal period, there is a higher under -five mortality rate respectively for 0–28 days/neonatal (43.2%) , 1-11 months/post-neonatal (40.7%) , and 12–59

months/child (16.1%). After assessing the relationship between mother's characteristics and under 5 Mortality/Survival, the following characteristics were statistically significantly associated with child survival (Table 12) mother working, mother over 29 years old, and child with either a documented weight at birth or mother who could recall the childbirth weight.

Table 12.

Household Socio-economic Factors and Mother's Characteristics and Under-five Survival

Characteristics		Child Status								
		Child Alive		Child Died		Total		95.0% CI		p-value
		N	%	n	%	N	%	Lower	Upper	
Mother education status	Some education	2,324	32.8%	191	28.0%	2,515	32.3%	0.73	1.10	0.295
	No education	4,769	67.2%	492	72.0%	5,261	67.7%	Ref	Ref	
Mother employment status	Working	5,036	71.0%	529	77.5%	5,565	71.6%	1.20	1.80	0
	Not working	2,057	29.0%	154	22.5%	2,211	28.4%	Ref		
Husband/partner education status	Some education	2,472	36.0%	214	32.5%	2,686	35.7%	0.79	1.17	0.678
	No education	4,398	64.0%	444	67.5%	4,842	64.3%	REf		
Mother husband or partner status	With a partner	6,058	85.4%	590	86.4%	6,648	85.5%	0.73	1.24	0.718
	Without a partner	1,035	14.6%	93	13.6%	1,128	14.5%	Ref		
Mother age	Older mother > 29 years	2,932	41.3%	315	46.1%	3,247	41.8%	1.28	1.82	0
	Young mother ≤29 years	4,161	58.7%	368	53.9%	4,529	58.2%	Ref		
Weight at birth/recall	Not weighted	2,635	37.1%	327	47.9%	2,962	38.1%	Ref		
	From written card	2,942	41.5%	114	16.7%	3,056	39.3%	0.23	0.36	0
	From mother`s recall	1,234	17.4%	157	23.0%	1,391	17.9%	1.03	1.61	0.03
	Don`t know	30	0.4%	13	1.9%	43	0.6%	1.85	8.03	0
	Special answers	252	3.6%	72	10.5%	324	4.2%	2.54	4.91	0

Results

A total of 7,776 children under 5 years old were examined from the surveyed women (15-49 years old) drawn from the merged 2005-2020 DHS datasets of Cote D'Ivoire. The majority (53.6%) of them were 12-59 months old child, followed by the 0-28 days (24.6%) neonatal, and 1-11 months/post-neonatal (21.8%).The vast majority (83%) had a birth card, and 70.8% received mother breast milk for at least six months. Most (58.2%) of the mothers enrolled were young and less than 30 years old. More than half (67.7%) of the mothers didn't have a formal education and the majority of them (85.5) were living with a male partner.

Among them, 49.5% (3852) were female and 5.5% (3924) males (Table 8). Of the sample observed, a total of 683 (8.8%) deaths were reported (Table 10) of which (43.2%) occurred between birth and 28 days (neonatal mortality), (40.7%) occurred between one (1) to 11 months (postnatal mortality), and (16.1%) occurred between 12 to 59 months (child mortality) (Table 10). Based on gender of the children died ,more than half of the children (61.6%) were male whilst 38.4% were female (Table 10).There is a higher proportion of deaths occurring in households with 1 or 0 children cared for respectively 47.3% for more than 2 children versus 52.7% for 1 or 0) (Table 10). Also, significantly lower proportions of children dying in Centre-Nord, Centre-Ouest and Sud-ouest.

Based on an analysis of the confounding factors in this study, most of the women and children under-five came from a rural (71.2%) versus urban (28.8%) setting (Table 10). Based on the household wealth, Richer households (45.2%) have a lower rate of

mortality versus Poorest households (54.8%) (Table 12). Male headed households have a higher under 5 mortality (86.2%) versus women Female headed households (13.8%) (Table 11). Furthermore, looking at education, the results show that a higher rate of under- five mortality are among mothers with no education (72.0%) versus (28.0%) for those with education (Tables 10 &12).

Multivariate Analysis (Cox Regression)

I fitted Cox proportional regression model to the data with the factors (WaSH) and confounding variables which included demographic, socioeconomic, and maternal variables to check the magnitude of their effect on the outcome variable (death of child or U5M). One considerable limitation of the model is associated with its own assumptions, including the proportionality assumption. This assumption assumes that the hazard ratio is constant over time, and this also could represent a limitation; therefore, care must be taken to test this assumption (Bewick et al., 2004). The proportionality assumption of the cox proportional regression method must be assessed. In fact, the model presumes that the ratio of the hazard functions for any two subgroups (i.e., two groups with different values of the explanatory variable X) is constant over time (Dickman, 2005). So, if the hazard functions cross, there is a possibility that the effect of the independent variable will not be statistically significant despite the presence of a clinically interesting effect. Therefore, it is essential to plot survival curves before fitting Cox proportional models. Among several methods to test this assumption, include a) Plot the cumulative survivor functions and check if they do not cross, b) Plot the log cumulative hazard functions over time and check if they are parallel, c) Include time-by-covariate interaction terms in the

model and test statistical significance, d) Plot Schoenfeld's residuals against time to identify patterns (Dickman, 2005).

Testing Cox Regression Assumption

As mentioned in the earlier section, the proportional hazard assumption is that the hazard function or hazard ratios for censored and uncensored groups are proportional over time, which means that the hazard ratio is constant over time. I tested the assumption prior to undertaking the full analysis through Cox regression model. I used the following approach to test the assumption:

- Visual examination of the Kaplan–Meier curves to check if there is a crossing of the Kaplan–Meier curves which indicate a violation of the assumption; or if rates of change of the two curves were not constant over time.
- Fitting a Cox regression model with the relevant factor, and testing for interaction with the time variable. In SPSS, the factor of interest (water, sanitation, hygiene), and the product of the time variable with the same factor (T_COV_) were added to the model. If a significant model can be developed ($p < 0.05$), then the proportional hazards assumption is not valid. If $p > 0.05$, then the proportionality assumption is valid. The results from the three factors of interest are given below.

Tests of Model Fit for Sanitation as the Factor or Explanatory Variable

- Cox regression model was fitted with relevant factors (sanitation) to test for interaction with time variables using SPSS, and the product of the time variable with the same factor (T_COV_) was added to the model. If a significant model can be developed with ($p < 0.05$), this indicates that the proportional hazards

assumption is not valid. Fortunately, in the present case $p>0.05$, as seen in Table 13 (Sig= 0.484).By fitting a Cox regression model with the relevant factor (sanitation), and a test for interaction with time variable (T_COV_) did not produce significant interactions. This means that the fitted model did not have time-dependent hazards. Which means that the proportionality assumption is met.

Table 13

Testing of interaction with sanitation and time variable using SPSS to diagnose the Cox proportionality assumption

Variables in the Equation

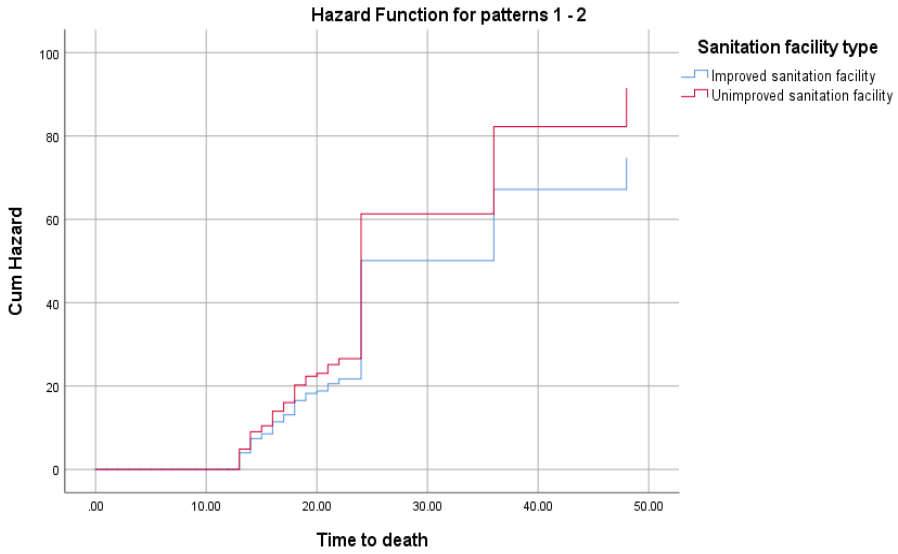
	B	SE	Wald	Df	Sig.	Exp(B)
T_COV_	0.005	0.009	0.295	1	0.587	1.005
Sanitation facility type	0.067	0.096	0.489	1	0.484	1.07

Proportional hazard assumption is valid ($p>0.05$) for the interaction.

Furthermore, as Figure 5 shows, the graphical plotting using Kaplan–Meier curves indicates two parallel curves which do not cross, and this implies that there is no violation of the assumption; or because the rates of change of the two curves were constant over time. In sum, fitting a Cox regression model with the relevant factor (sanitation), and testing for interaction with the time variable (T_COV_) did not produce significant interactions. Moreover, the curves were parallel as expected for a valid proportional hazard context. This means that the fitted model did not have significant time-dependent hazards. I concluded that the fitted model shows that the proportionality assumption for Cox regression is met.

Figure 5.

Testing assumption for Hazard function by type of Sanitation facility (Patterns 1-2)



Tests of Model Fit: Water as the Independent Variable

For this model, tests show model assumptions holding: (1) survival curves for different strata must have hazard functions that are proportional over the time and (2) the relationship between the log hazard and each covariate is linear. Fitting a Cox regression model with the relevant factor (water), and testing for interaction with the time variable (T_COV_) did not produce significant interactions. This means that the fitted model did not have significant time-dependent hazards.

- Cox regression model was fitted with a relevant factor (water) to test for interaction with the time variable using SPSS, and the product of the time variable with the same factor (T_COV_) was added to the model. If a significant model can be developed with ($p < 0.05$), this indicates that the proportional hazards assumption is not valid. Fortunately, in the present case $p > 0.05$, as seen in Table

14 (Sig=.892) .By fitting a Cox regression model with the relevant factor (water), and testing for interaction with time variable (T_COV_) did not produce significant interactions. This means that the fitted model did not have time-dependent hazards and the proportionality assumption is met.

Table 14.

Testing of interaction with Water and time variable using SPSS to diagnose the Cox proportionality assumption

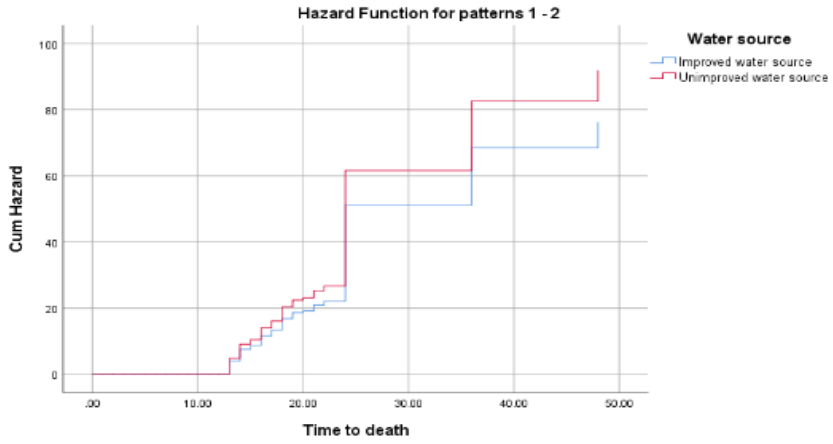
	B	SE	Wald	Df	Sig.	Exp(B)
T_COV_	0.001	0.009	0.014	1	0.906	1.001
Water source	0.015	0.109	0.018	1	0.892	1.015

Proportional hazard assumption is valid ($p>0.05$) for the interaction.

Furthermore, as Figure 6 shows, the graphical plotting using Kaplan–Meier curves indicates two parallel curves which do not cross, and this implies that there is no violation of the assumption; or because the rates of change of the two curves were constant over time. In sum, fitting a Cox regression model with the relevant factor (sanitation), and testing for interaction with the time variable (T_COV_) did not produce significant interactions. Moreover, the curves were parallel as expected for a valid proportional hazard context. This infer that the fitted model did not have significant time-dependent hazards. I concluded that the fitted model shows that the proportionality assumption for Cox regression is met.

.Figure 6

Testing assumption. Testing assumption for Hazard function by type of Water source (Patterns 1-2)



Tests of Model Fit: Hygiene the Independent Variable

For this model, tests show model assumptions holding: (1) survival curves for different strata must have hazard functions that are proportional over the time and (2) the relationship between the log hazard and each covariate is linear.

- Cox regression model was fitted with relevant factor (hygiene) to test for interaction with time variable using SPSS, and the product of the time variable with the same factor (T_COV_) was added to the model. If a significant model can be developed with ($p < 0.05$), this indicates that the proportional hazards assumption is not valid. Fortunately, in the present case $p > 0.05$, as seen in Table 15 (Sig=.410) . By fitting a Cox regression model with the relevant factor (hygiene), and testing for interaction with time variables (T_COV_) did not

produce significant interactions. This means that the fitted model did not have time-dependent hazards, implying that the proportionality assumption is met.

Table 15.

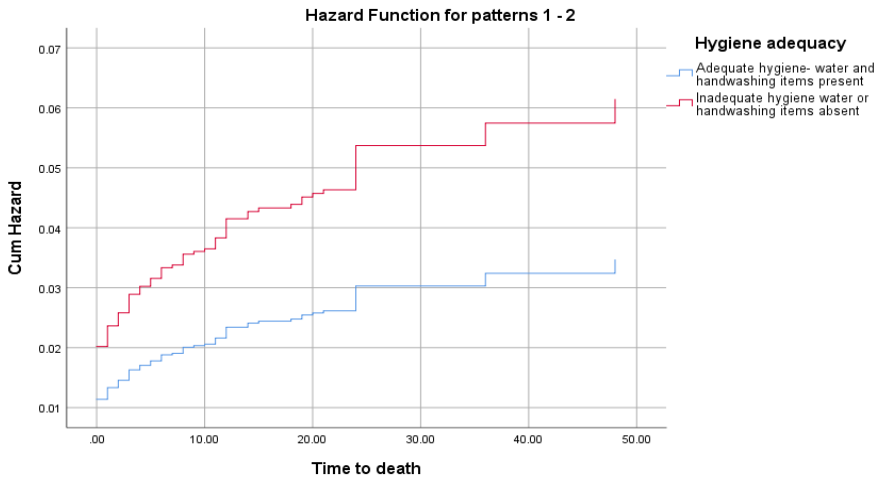
Testing of interaction with hygiene and time variable using SPSS to diagnose the Cox proportionality assumption

	B	SE	Wald	Df	Sig.	Exp(B)
T_COV_	0.005	0.015	0.124	1	0.724	1.005
Hygiene adequacy	0.142	0.173	0.678	1	0.41	1.153

In addition, as figures 7 indicates, the graphical plotting using Kaplan–Meier curves indicate two parallel curves which do not cross, and this implies that there is no violation of the assumption; or because the rates of change of the two curves were constant over time. In sum, fitting a Cox regression model with the relevant factor (sanitation), and testing for interaction with the time variable (T_COV_) did not produce significant interactions. Moreover, the curves were parallel as expected for a valid proportional hazard context. This infers that the fitted model did not have significant time-dependent hazards. I concluded that the fitted model shows that the proportionality assumption for Cox regression is met.

Figure 7

Testing assumption. *Testing assumption for Hazard function by hygiene adequacy (Patterns 1-2)*



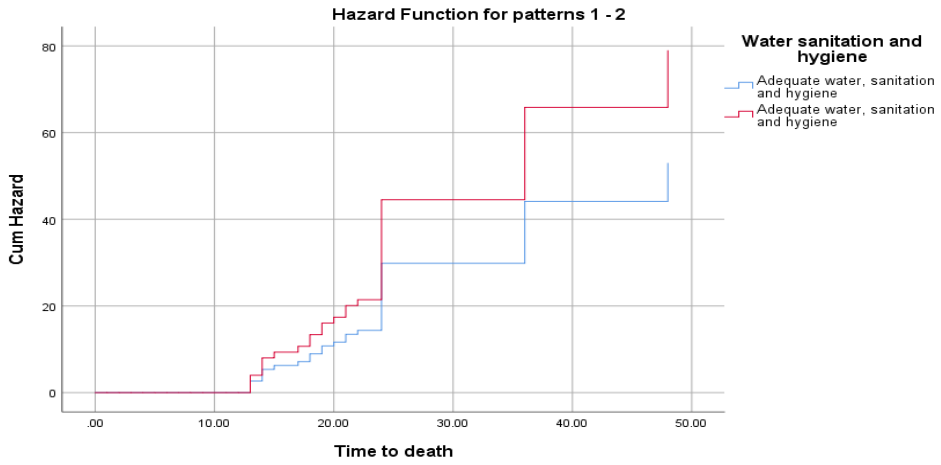
Tests of Model Fit: WaSH

The baseline hazard is proportional if the graphs are parallel to each over; therefore, do not cross. Given the elements cited above, these curves are parallel (Figure 8) ; hence do not cross. Assuming that my visual observation is accurate, so I concluded that the assumption of proportionality is appropriate; hence, has been met. However, as Xue et al. (2013) suggested "graphical methods involve a moderate degree of subjectivity in interpretation" (p. 2). Given the facts described above, I concluded that the assumption of proportionality is met; therefore, my planned methodology will not be affected by a potential non-proportionality element in dealing with the present research design and method. Graphical approaches are a visual form of screening for non-proportionality which can provide insight into the temporality and the extent of non-

proportionality that is otherwise difficult to obtain using statistical methods (Xue et al., 2013, p.2).

Figure 8

Testing assumption: WaSH variables



Research Question1(RQ1):To what extent does access to improved sanitation facilities affect the under-five mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic , and maternal variables

The null hypothesis (H01):There is no statistically significant difference in the under 5 mortality while controlling for demographic ,socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without.

*The alternative hypothesis (HA1):*There is statistically significant difference in the under 5 mortality while controlling for the demographic ,socioeconomic, and

maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without

For Research Question 1, I conducted Cox proportional regression analysis to examine the effect of access sanitation facilities on the under 5 mortality among women 15-49 while controlling for demographic, socioeconomic, and maternal variables.

The results show that there is a statistically significant difference in the under-five mortality associated with access to sanitation facilities (p=0.013). It implies that children from households using unimproved sanitation facilities have a higher risk of death 1.224 times more (HR: 1.224, 95% CI: 1.044- 1.435) as compared to those coming from households with improved sanitation facilities (Table 17).

Based on the results, there is a statistically significant relationship between the under-five mortality and access to improved sanitation sources (Sig=0.013 <0.05) (Table 17); I therefore reject the null hypothesis in favor of the alternative. I concluded that women with unimproved access to sanitation facilities have (22%) risk of under-five mortality compared to counterparts with improved sanitation facilities.

Beside the hazard ratio in the model, the chi square ($\chi 2$) test often tests for evidence of any difference in the survival functions across all strata for categorical variables or for a unit increase for continuous variables (Wilson, 2018). The model is valid if the omnibus tests of model coefficients are significant (that is, $p < 0.05$). Thus, the fitted model suggested that the coefficients of the model are non-zero ($\chi 2$=1785.982, P=000<0.05) suggesting that the model best fit the data. The p-value or Sig = 000 less than 0.05 (Table 16) indicates sufficient evidence of a clear association between the risk

of death and the study of independent variables and confounders included in the model. In sum, the results from the omnibus test showed the model is statistically significant, p = 000 < alpha = .05, thus the model adequately predicts the effect of the independent variables on under 5 mortality (See Tables 16).

Table 16.

Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	Df	Sig.	Chi-square	Df	Sig.	Chi-square	df	Sig.
10096.389	1552.17	10	0	1785.98	9	0	1785.98	9	0

Table 17.

Variables in the Equation

	Variables in the Equation							
Variables	B	SE	Wald	Df	Sig.	Exp(B)	95.0% CI	
							Lower	Upper
Sanitation facility type	0.20	0.081	6.233	1	0.013	1.224	1.04	1.44
Under-five mortality age group			1.531	2	0.465			
Under-five mortality age group (1)	-11.42	17.753	0.414	1	0.52	0	0.00	1.4E+10
Under-five mortality age group (2)	-22.82	20.771	1.207	1	0.272	0	0.00	5.9E+07
Mother education status	0.32	0.087	13.573	1	0	1.378	1.16	1.63

Mother employment status	-0.36	0.093	14.923	1	0	0.698	0.58	0.84
Mother age	-0.31	0.08	15.352	1	0	0.731	0.63	0.86
Weight at birth/recall	0.21	0.037	32.689	1	0	1.233	1.15	1.32
Household size	-0.17	0.118	1.987	1	0.159	0.846	0.67	1.07
Gender of child	-0.41	0.079	26.874	1	0	0.664	0.57	0.78
Number of under 5 cared for	0.84	0.084	99.014	1	0	2.317	1.96	2.73

Water

Research Question 2 (RQ2):To what extent access to improved water sources affect the under 5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic ,and maternal variables ?

The null hypothesis (H02):There is no statistically significant difference in the under 5 mortality while controlling for the demographic ,socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

The alternative hypothesis (HA2) :There is a statistically significant difference in the under 5 mortality while controlling for the demographic ,socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without .

For Research Question 2, I conducted cox proportional regression analysis to examine the effect of access to improved water sources on the under 5 mortalities among women 15-49 while controlling for demographic, socioeconomic, and maternal variables.

The results indicate that there is a statistically significant difference in the under-five mortality associated with access to improved water sources (p=0.050). Based on the level of hazard from the inferential analysis, women from households using unimproved water sources have a higher risk of U5M 1.205 time more (HR: 1.205, 95% CI: 1.000- 1.453) (p=0.050) as compared to those coming from households with improved water sources (Table 19). Looking at both the confidence interval and the P value, this result appears statistically significant (Sig=0.050 < or equal 0.05) and CI: (1.000- 1.453). I, therefore, rejected the null hypothesis in favor of the alternative. I concluded that women with access to unimproved water sources have (20%) risk of under 5 mortality compared to counterparts with improved water sources. The fitted model was significant (with Sig less than 0.05); therefore the method is justified and valid (Table 18).

Table 18.

Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	Df	Sig.	Chi-square	Df	Sig.	Chi-square	df	Sig.
10014.503	1664.297	20	0	1615.81	6	0	1615.81	6	0

a. Beginning Block Number 3. Method = Enter

Table 19.

Variables in the Equation

Variables	Variables in the Equation							
	B	SE	Wald	Df	Sig.	Exp(B)	95.0% CI	
							Lower	Upper
Water source	0.19	0.10	3.84	1	0.05	1.21	1.00	1.45
Gender of child	-0.37	0.08	22.17	1	0.00	0.69	0.59	0.81
Number of under 5 cared for	0.94	0.08	142.85	1	0.00	2.56	2.19	2.98
Place of residence	0.25	0.10	6.14	1	0.01	1.28	1.05	1.57
Region			91.20	10	0.00			
Region (1)	-0.17	0.19	0.78	1	0.38	0.85	0.58	1.23
Region (2)	-0.38	0.21	3.17	1	0.08	0.69	0.45	1.04
Region (3)	-0.61	0.22	7.96	1	0.01	0.54	0.35	0.83
Region (4)	0.48	0.16	8.44	1	0.00	1.61	1.17	2.22
Region (5)	0.01	0.19	0.00	1	0.98	1.01	0.70	1.45
Region (6)	0.58	0.16	13.62	1	0.00	1.78	1.31	2.41
Region (7)	-0.02	0.19	0.01	1	0.92	0.98	0.68	1.41
Region (8)	-0.31	0.21	2.12	1	0.15	0.74	0.49	1.11
Region (9)	-0.46	0.22	4.57	1	0.03	0.63	0.41	0.96
Region (10)	-0.02	0.21	0.01	1	0.92	0.98	0.65	1.47
Under-five mortality age group			1.53	2	0.47			
Under-five mortality age group (1)	-11.44	17.86	0.41	1	0.52	0.00	0.00	17109807
Under-five mortality age group (2)	-22.83	20.86	1.20	1	0.27	0.00	0.00	69982596
Mother education status	0.17	0.09	3.71	1	0.05	1.19	1.00	1.42
Mother employment status	-0.37	0.09	15.83	1	0.00	0.69	0.57	0.83
Mother age	-0.26	0.08	10.58	1	0.00	0.78	0.67	0.90
Weight at birth/recall	0.25	0.04	48.46	1	0.00	1.29	1.20	1.39

Hygiene

Research Question 3(RQ3): To what extent does adequate hygiene affect the under 5 mortalities among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H03): There is no statistically significant difference in the under-five mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

The alternative hypothesis (HA3): There is a statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without

For Research Question 3, I conducted cox proportional regression analysis to examine the effect of adequate hygiene on the under 5 mortalities among women 15-49 while controlling for demographic, socioeconomic, and maternal variables. The results indicate that there is a statistically significant difference in the under 5 mortality associated with adequate hygiene (p=0.013). It implies that women from households using inadequate hygiene have a higher risk of under 5 deaths 1.773 times more (HR: 1.773 ,95% CI: 1.129- 2.784) (p=0.013) as compared to those coming from households with adequate hygiene (Table21).

Based on the results, there is a statistically significant relationship between the under-five mortality and adequate hygiene (Sig= P=0.013<0.05); I therefore, rejected the null hypothesis in favor of the alternative. I concluded that women with access to inadequate hygiene have (77%) risk of under 5 mortality compared to counterparts with adequate hygiene. The fitted model was significant (with Sig less than 0.05); therefore the method is justified and valid (Table 20).

Table 20.

Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	Df	Sig.	Chi-square	Df	Sig.	Chi-square	Df	Sig.
1864.896	115.969	19	0	16.957	1	0	16.957	1	0

a. Beginning Block Number 3. Method = Enter

Table 21.

Variables I n the Equation

Variables	Variables in the Equation							
	B	SE	Wald	Df	Sig.	Exp(B)	95.0% CI	
							Lower	Upper
Hygiene adequacy	0.57	0.23	6.18	1	0.01	1.77	1.13	2.78
Mother education status	-0.09	0.18	0.25	1	0.62	0.91	0.64	1.30
Mother employment status	0.02	0.20	0.01	1	0.93	1.02	0.69	1.50
Mother age	-0.26	0.18	2.08	1	0.15	0.77	0.54	1.10
Weight at birth/recall	1.27	0.19	45.09	1	0.00	3.54	2.45	5.13
Household size	0.17	0.28	0.40	1	0.53	1.19	0.69	2.05
Gender of child	-0.52	0.18	8.21	1	0.00	0.59	0.42	0.85

Number of <5 cared for	0.88	0.19	20.46	1	0.00	2.40	1.64	3.51
Region			14.55	10	0.15			
Region (1)	0.85	0.47	3.31	1	0.07	2.35	0.94	5.88
Region (2)	0.17	0.50	0.12	1	0.73	1.19	0.45	3.13
Region (3)	-0.08	0.49	0.03	1	0.87	0.92	0.35	2.42
Region (4)	0.66	0.48	1.90	1	0.17	1.93	0.76	4.94
Region (5)	0.58	0.44	1.71	1	0.19	1.79	0.75	4.26
Region (6)	1.07	0.44	5.86	1	0.02	2.92	1.23	6.96
Region (7)	0.08	0.45	0.04	1	0.85	1.09	0.45	2.63
Region (8)	0.50	0.43	1.38	1	0.24	1.65	0.72	3.79
Region (9)	0.08	0.51	0.02	1	0.88	1.08	0.40	2.95
Region (10)	0.52	0.39	1.74	1	0.19	1.68	0.78	3.64
Birth weight in kilograms (2 decimals)	-0.46	0.12	16.07	1	0.00	0.63	0.50	0.79

Water, Sanitation, and Hygiene Combined

Research Question 4 (RQ4): To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under 5 mortality among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H04): There is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

The alternative hypothesis (HA4): There is a statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved

water sources, improved sanitation facilities, and adequate hygiene and those without.

For Research Question 4, I conducted cox proportional regression analysis to examine the effect of adequate hygiene on the under 5 mortalities among women 15-49 while controlling for demographic, socioeconomic, and maternal variables.

The results indicate that there is a statistically significant difference in the under-five mortality associated with improved WaSH variables (p=0.039). It implies that women from households using Unimproved WaSH variables have a higher risk of under 5 death 1.491 time more (HR: 1.491 [95% CI: 1.021- 2.178] (p=0.039) as compared to those coming from households with improved WaSH variables (Table 23).

Based on the results, there is statistically significant relationship between the under-five mortality and improved WaSH (Sig= P=0.039<0.05); I, therefore, rejected the null hypothesis in favor of the alternative, and concluded that women residing in households with adequate hygiene, improved water source ,and improved sanitation facilities have lower risk of death compared to counterparts living in households with inadequate hygiene ,unimproved water source ,and unimproved sanitation facilities. I concluded that women with access to unimproved WaSH conditions have (49%) risk of under 5 mortality compared to counterparts with improved WaSH. The fitted model was significant (with Sig less than 0.05); therefore the method is justified and valid (Table 22).

Table 22.

Omnibus Tests of Model Coefficients

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	Df	Sig.	Chi-square	Df	Sig.	Chi-square	Df	Sig.
3838.607	680.667	10	0	773.446	9	0	773.446	9	0

a. Beginning Block Number 2. Method = Enter

Table 23.

Variables in the Equation

Variable	Variables in the Equation							
	B	SE	Wald	Df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Water sanitation and hygiene	0.40	0.19	4.28	1	0.04	1.49	1.02	2.18
Under-five mortality age group			0.66	2	0.72			
Under-five mortality age group (1)	-11.43	26.77	0.18	1	0.67	0.00	0.00	6.7E+17
Under-five mortality age group (2)	-22.82	31.45	0.53	1	0.47	0.00	0.00	7.2E+16
Mother education status	0.29	0.13	5.43	1	0.02	1.34	1.05	1.71
Mother employment status	-0.24	0.13	3.29	1	0.07	0.79	0.60	1.02
Mother age	-0.25	0.12	4.08	1	0.04	0.78	0.61	0.99
Weight at birth/recall	0.21	0.06	14.06	1	0.00	1.24	1.11	1.38
Household size	0.08	0.19	0.16	1	0.69	1.08	0.74	1.58
Gender of child	-0.61	0.13	23.84	1	0.00	0.54	0.43	0.69
Number of under 5s cared for	0.82	0.13	41.38	1	0.00	2.27	1.77	2.91

Summary

RQ1 examined to what extent improved sanitation facilities affect the under 5 mortalities among women 15-49 in Cote D'Ivoire while controlling for Demographic, socioeconomic, and maternal variables?

The null hypothesis (H01) was that there is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without. The alternative hypothesis (HA1) was that there is a statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved sanitation facilities and those without. The model parameter estimates included the hazard ratio along with p-values and 95% confidence intervals for the coefficients. The P value was 0.013 at 95% confidence interval CI ranging between lower 1.044 and upper 1.435).The hazard ratio just like an Odds Ratio is about HR:1.224. Based on these statistics, it appeared that there is statistically significant difference in the under-five mortality associated with access to improved sanitation sources (P= 0.013) and this infer that those women residing in households using improved sanitation facility have a lower risk of under 5 mortalities (HR:1.224, 95% CI: 1.044- 1.435) versus those from households with unimproved sanitation facilities. The dependent variable was under 5 mortality and the independent variable was sanitation facilities given the range of confidence interval and P value lower than 0.05, I reject the Null Hypothesis. Therefore, I concluded that the risk of hazard in U5 mortality among

women 15-49 while controlling for demographic, socioeconomic, and maternal variables was lower in those who have access to improved sanitation facilities (P=0.013) compared to counterparts with no improved sanitation facilities. In another word, women with unimproved access to sanitation facilities have (22.4%) risk of under 5 mortality compared to counterparts with improved sanitation facilities.

Research Question 2: To what extent does access to improved water sources affect the under 5 mortalities among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H02) was that there is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without. The alternative hypothesis (HA2) was that there is a statistically significant difference in the under-five mortality while controlling for the demographic ,socioeconomic , and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources and those without.

I conducted cox proportional hazard regression model and water sources were independently examined with the socioeconomic , demographic , and maternal variables that were significantly associated with mortality, and those variables with p-values < 0.05 were retained .The research question two examined the magnitude of access to improved water sources impact the under 5 mortality among women aged between 15-49 in Cote D'Ivoire. In research question 2, all the variables included in the model are categorical, mortality was coded as zero if it did not occur and one if it occurred. For this cox

regression, death/mortality (mortality occurring) was the dependent variable. Water sources are grouped into improved water source and unimproved water source (unimproved water source was the reference group). The parameter estimates from the Cox proportional hazard model indicates that the likelihood of dying (mortality) is approximately 1.205 time more (HR :1.205 , 95% CI: 1.000- 1.453) (p=0.050) in households using unimproved water sources versus those residing in households with improved water sources. *P value 0. 050.*Therefore, I reject the null hypothesis; thereafter and state that the effect of improved water sources on under-5 mortality was statistically significant (p=0.050).

Therefore, I concluded that the risk of hazard in U5 mortality among women 15-49 while controlling for demographic, socioeconomic , and maternal variables was lower in those who have access to improved water sources compared to counterparts with unapproved water sources. In another word, women with unimproved water sources have (20.5%) risk of under 5 mortality compared to counterparts with improved water sources. Research question 3: *To what extent does adequate hygiene affect the under 5 mortalities among women 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?*

The null hypothesis (H03) was that there is no statistically significant difference in the under-five mortality while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without. The alternative hypothesis (HA3) was that there is a statistically significant difference in the under 5 mortalities while controlling for the demographic,

socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with adequate hygiene and those without.

Using Cox proportional hazard regression, I examined the relationship between hygiene and mortality. Mortality was coded as 0 if it did not occur and 1 if it occurred. For this Cox regression, death or mortality was the dependent variable and hygiene variables are grouped into two groups e.g., adequate, and inadequate hygiene (Inadequate hygiene was the reference group).The parameter estimates from the Cox proportional hazard model indicated that the likelihood of dying (under 5 mortality) is approximately 1.773 time higher (HR: 1.773 ,95% CI: 1.129- 2.784) (p=0.013) among women residing in households with inadequate hygiene than those residing in households with adequate hygiene .This result is statistically significant because the 95% confidence interval does not include 1 and *P value* 0.013 *less than 0.05* .I rejected the null hypothesis; thereafter and state that the effect of adequate hygiene on under-5 mortality was statistically significant (p=0.013). Inadequate hygiene is a significant contributable risk factor for the U5 Mortality. I concluded that the risk of hazard in U5 mortality among women 15-49 while controlling for demographic, socioeconomic , and maternal variables was lower in those with adequate hygiene compared to counterparts with inadequate hygiene. In another word, women with adequate hygiene have (77.3%) increase of under-five mortality compared to counterparts with inadequate hygiene.

Research question 4: *To what extent does access to improved water sources, improved sanitation facilities, and adequate hygiene affect the under 5 mortalities among women*

15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables?

The null hypothesis (H04) was that there is no statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without.

The alternative hypothesis (HA4) was that there is a statistically significant difference in the under 5 mortalities while controlling for the demographic, socioeconomic, and maternal variables among women 15-49 in Cote D'Ivoire with access to improved water sources, improved sanitation facilities, and adequate hygiene and those without. Using cox proportional hazard regression, I examined the relationship between the combined effect of water, sanitation, and hygiene on mortality. As previously mentioned, mortality was coded as 0 if it did not occur and 1 if it occurred. For this Cox regression, death/mortality were the dependent variables and water, sanitation, and hygiene variables were simultaneously examined as exposure variables. The parameter estimates from the Cox proportional hazard model for the multivariate analysis indicated that the likelihood of dying (mortality before age 5) is 1.491 time higher (HR: 1.491 [95% CI: 1.021- 2.178] (p=0.039) among women living in households with inadequate hygiene ,unimproved water source, and unimproved sanitation facilities versus those residing in households with adequate hygiene, improved water source ,and improved sanitation facilities. The result is statistically significant because the 95% confidence interval does not include 1 and *P value* p= 0.039 *less than 0.05*. I rejected the null hypothesis;

thereafter and I state that the interaction between improved water and sanitation, and hygiene impact on under 5 mortality was statistically significant, with (p= 0.039).

I concluded that the risk of hazard in U5 mortality among women 15-49 while controlling for demographic, socioeconomic , and maternal variables was lower in those who with adequate hygiene, improved water source ,and improved sanitation facilities compared to counterparts with inadequate hygiene ,unimproved water source, and unimproved sanitation facilities. In another word, women with improved WaSH have (49.1%) increase of under-five mortality compared to counterparts with unimproved WaSH.

In sum, this chapter presented the results of the survival analysis using Cox proportional hazard regression method to examine the magnitude of the relationship between access to improved WaSH and the under 5 mortality rates among women 15-49 in Cote D'Ivoire using all available and relevant Cote D'Ivoire DHS data from 2005-2020. In chapter 5, I discuss the results of this study in relation to previous related literature regarding WaSH and under 5 mortality. Moreover, I provide recommendations for further research and limitations along with social change implications.

Chapter 5: Discussion, Conclusions, and Recommendations

This quantitative cross-sectional correlational study aimed to examine the magnitude of the association between access to WaSH affecting the under 5 childhood death rates in Cote D'Ivoire. The study used a sample containing women aged 15-49 years with children aged 0 -59 months from pooled Cote D'Ivoire DHS data sets: 2005-2020. The IBM-WASH and the health and human rights framework were used as the conceptual framework. I conducted Cox proportional hazards method to assess the relation between WaSH variables and their effect on U5MR. This research focused on access to WaSH as independent variables and their effect on the under 5 mortalities as the dependent variable. I used a survival analysis, specifically Cox proportional hazard regression model, to answer Research Question 1, 2, 3 and 4. Below, I interpret and discuss the results.

Interpretation of Results

In this analysis, I used CI (confidence interval) and P Values when relevant to interpret the inferential statistics from this study. For example, I used CI to indicate the range within which a population parameter was likely to be found. The intervals for each null hypothesis were in line with this study sample set at a 95% CI, which was equal to (α=0.05) alpha level of significance of 0.05. The lower alpha equal to or less than 0.05, the higher likelihood to reject the null hypothesis.

Research Question 1 (RQ1) examined to what extent improved sanitation facilities affect the under 5 mortalities among women aged between 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables. As explained before, I used a survival analysis model, namely Cox proportional hazard regression. Using Cox proportional regression the model parameter estimates included the hazard ratio (HR) along with p-values and 95% CI for the coefficients. The P-value was P= 0.013 at a 95% confidence interval ranging between lower 1.044 and upper 1.435. The hazard ratio HR: 1.224 and indicated that there is a statistically significant difference in the under 5 mortality associated with access to improved sanitation sources (p=0.013). The U5MR among women is higher in households using unimproved sanitation facilities (HR:1.224, 95% CI: 1.044- 1.435) as compared to those coming from households with improved sanitation facilities. The results are statistically significant, as one was not in the range of the CI and the P-value =0.013 was less than 0.05; therefore I rejected the null hypothesis. Rejecting the null hypothesis implies that there is enough evidence to say sanitation is a contributing predictor of the under 5 mortalities among women 15-49 years. Therefore, I can say that the under 5 mortality was statistically and significantly associated with those who have access to improved sanitation facilities (p=0.013) as compared to counterparts with no improved sanitation facilities. Of the sample observed, a total of 683 (8.8%) deaths were reported (Table 8), of which (43.2%) occurred between birth and 28 days (neonatal mortality), (40.7%) occurred between 1 and 11 months (postnatal mortality), and (16.1%) occurred between 12 and 59 months (child mortality) .

In the research Question 1, the findings of an increased risk of death for those using unimproved sanitation versus those not using improved sanitation, in tandem with what Ezeh and associates have done recently. In their study, Ezeh et al (2014) using multivariate analyses have examined the combined effect of water and sanitation on under 5 mortalities (i.e., neonatal, post-neonatal, and child mortality) after adjustment of confounders. Their results showed that neonates born to mothers in households with access to both unimproved water and sanitation had a higher risk of neonatal death (HR = 1.06; CI: 0.85—1.23) compared with the reference category (improved water and improved sanitation), though their result was not statistically significant.

Other studies from Fink and associates (2011) used merged DHS data with water and sanitation to examine several outcomes including infants' diarrhea, mortality, and stunting. The authors found lower mortality with improved sanitation (OR = 0.77), a lower risk of diarrhea (OR = 0.87), and a lower risk of mild or severe stunting (OR = 0.73). The result showed slight protective effects than reported in previous literature. These findings underlined a significant health impact of children in low-and middle-income nations without access to sanitation and water (Fink et al., 2011). The results could be explained as infant children generally get most of their nutrition from breastfeeding; this may reduce their direct exposure to the effect of water and sanitation. This study as well as current research indicates a protective effect of access to improved sanitation on under 5 survivals. As Alemu (2017) pointed out, proper sanitation can substantially reduce the main risk factors for child death, including undernutrition, diarrhea, and pneumonia; therefore, the author concluded that addressing issues

associated with access to sanitation is critical to minimize childhood death rates by 2/3. In Research Question 1, from a clinical standpoint, the result indicates a lower risk of death for those using improved sanitation versus those not using improved sanitation; however, these numbers are not statistically significant as mentioned earlier.

Similarly, Diouf et al. (2014) undertook their cross-sectional survey among children under 5 and related morbidity in rural Burundi. Their study enrolled 903 children residing in 551 households and found out that 33% of these children had diarrhea, 46% used improved water facilities, and 3% had access to improved sanitation. The results did not report the effect of sanitation on the outcome variable, probably due to insufficient statistical evidence of the effect of improved sanitation on children's health outcomes as death. However, the researchers found a lower prevalence of diarrhea among those linked to caretakers with education in hygiene (18%) and who boiled water (19%) . In sum, they concluded that the prevalence of diarrhea can drop through hygiene education and household water treatment. Therefore, they suggested ongoing hygiene education in households and communities for a greater impact on children's health (Diouf et al., 2014).

In Kenya, similar research was undertaken by Garrett and colleagues in 2008. The researchers compared the rates of diarrhea in 960 under 5 children in 18 randomly selected villages (six comparisons versus 12 intervention) and 556 households. Over an 8-week period, the authors conducted home visits every week to evaluate the effect of the household latrine, water treatment, shallow wells, and rainwater harvesting on incident diarrhea among children less than 5 years old. Their results showed that those who live in the intervention villages, using rainwater, and the presence of a latrine were

independently associated with a lower risk for diarrhea. Diarrhea risk was greater among shallow wells users. Finally, the researchers concluded that using latrines, rainwater, and chlorinating stored water minimized the risk of diarrhea and that combining interventions may improve health outcomes (Garrett et al., 2008).

Research Question 2 (RQ2) examined to what extent improved water sources affect the under 5 mortalities among women aged between 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables.

In answering Research Question 2, I used the Cox proportional hazard regression model to assess the risk of death among those living in a household with improved water sources and those without. These water sources were independently examined with all possible confounders including socioeconomic, demographic, and maternal variables that were significantly associated with mortality, and those variables with p-values < 0.05 were retained (Model 2). Water sources were categorized into improved water sources and unimproved water sources. The parameter estimates from the Cox proportional hazard model has shown that the likelihood of dying (before reaching 5 years) is 1.205 time more (HR:1.205, 95% CI: 1.000- 1.453) (p=0.050) higher among women residing in households with access to unimproved water sources than those residing in households with access to improved water sources. The 95% confidence interval does not include one and *P-value 0. 050.* Therefore, I rejected the null hypothesis; thereafter, I state that the impact of improved water sources on under-5 mortality was statistically significant (p=0.050).

The result of this study is in tandem with what Ezeh and associates reported in their study. As mentioned earlier, Ezeh et al. (2014) examined the impact of sanitation and water on children under 5 mortalities, the authors found that unimproved water and sanitation significantly increased the risk of post-neonatal and child mortality; however, their result like this current study had no statistically significant effect on the risk of neonatal mortality. This is also in alignment not only with Ezeh et al. 's research, but also similar pattern was found in several studies including studies undertaken in Egypt and Eritrea, as noted by Ezeh et al. In these studies, the researchers reported that the impact of household environmental factors is very weak during the neonatal period; however, there was a large and statistically significant impact during the post-neonatal and child periods. As Ezeh et al. noted, this can be explained by the exclusive breastfeeding diet of children earlier in their life. Breastfeeding has already been proven to be protective to an infant's survival, increases immunity, and decreases the risk of prolonged diarrhea; neonates are less likely to be exposed to pathogens in contaminated water. The significant impact of breastfeeding during the neonatal and post neonatal time confirmed breastfeeding protective effect in minimizing the risk of infant death (Ezeh et al., 2014).

Given the explanation above, the investigators concluded that in highly vulnerable settings, programs for water and sanitation could have a significant influence in reducing health inequalities, yet mortality and morbidity in the under 5, as this was the case in the present study. This perspective resonates well with previous literature. Angoua et al. (2018) noted that despite all the progress done to achieve access to safe WS sources, still these elements are challenging for SSA nations. In an attempt to explain what triggers

access to WS in these regions, Angoua et al. through a correlational study examined the ability to access improved sanitation and water in urban settlements habitants to identify factors that predict access to guide tackle environmental risks and associated health issues. The authors undertook a cross-sectional study design in six poor settlements of Yopougon. The researchers found that approximately 25% of all households did not have access to clean water and 57% lacked improved sanitation. In peri-urban areas, these settlement characteristics and SES were found to be the main predictors for poor access to reliable water and sanitation services. Moreover, having a household head's spouse was 3.57 more likely to get access to clean water than the absence of a household head wife. This emphasized the importance of women to sustain potable water at home in these settings. Therefore, the authors recommended that women should be engaged at all levels of programming for promoting water in these places to enhance the population's well-being (Angoua et al., 2018, p.1).

RQ3 examined to what extent hygiene affects the under 5 mortalities among women aged between 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables.

Research Question 3 examined the risk difference in mortality between those with inadequate hygiene compared to those living in households with adequate hygiene. When answering Research Question 3 using the Cox proportional regression model, groups with adequate hygiene were 1.773 times (HR: 1.773,95% CI: 1.129- 2.784) (p=0.013) less likely to die versus those with inadequate hygiene. I, therefore, rejected the null

hypothesis and concluded that there is enough evidence to say that adequate hygiene can be a contributing predictor for under-five mortality in this group.

Similar to the current study, Dreibelbis et al. (2013) also reported in their experimental study (a cluster-randomized trial: CRT) examining the impact of school-based WaSH programs on outcomes related to diarrhea among children. The authors found out, among water stretched schools, improvement in WaSH holistically were linked to a reduction of the odds of diarrhea (odds ratio [OR] = 0.44; 95% confidence interval [CI] = 0.27, 0.73) and visiting a clinic (OR = 0.36; 95% CI = 0.19, 0.68), relative to control schools (Dreibelbis et al., 2013). However, they did not find a statistical difference in the groups with high access to water; water treatment interventions; school sanitation improvements; and school hygiene promotion was not linked with differences in prevalent diarrhea between control and intervention schools (Dreibelbis et al., 2013).

Research Question 4 examined the extent to which access to improved water and sanitation sources and hygiene affect the under 5 mortalities among women aged between 15-49 in Cote D'Ivoire while controlling for demographic, socioeconomic, and maternal variables. Research Question 4 examined whether there is a significant difference in risk of mortality between those living in a household with access to WaSH variables and those without access. In answering Research Question 4, I conducted a multivariate survival analysis through Cox proportional regression model to examine the effect of WaSH variables and their magnitude in risk of mortality among women 15-49 children under 5 years old. Given the Cox proportional ratio, the results were statistically significant and suggested that the likelihood of U5 mortality was 1.491 times less (HR:

1.491 [95% CI: 1.021- 2.178] (p=0.039) among women living in households with adequate hygiene, improved water source, and improved sanitation facilities versus those living in households with inadequate hygiene, unimproved water source, and unimproved sanitation facilities.

Similar to the current study, Dreibelbis et al.'s (2013) study found no statistical difference in their study groups with high access to water, water treatment interventions, and school sanitation improvements; moreover, they found that school hygiene promotion was not associated with differences in prevalent diarrhea between control and intervention schools. As mentioned earlier, these authors noted that among water stretched schools, improvement in WaSH holistically were associated with a reduction of the odds of diarrhea (OR = 0.44; 95% CI = 0.27, 0.73) and visiting a clinic (OR = 0.36; 95% CI = 0.19, 0.68), relative to control schools (Dreibelbis et al., 2013). Given the above, Dreibelbis et al. concluded that in water-stretched places, intervention for WaSH in schools with robust water facilities improvements can minimize diarrhea illnesses in childhood.

Even though this study is not specifically about children's mortality issues, because mortality itself is induced generally by morbid situations such as diarrheal illnesses, respiratory diseases, stunting, undernutrition, and pneumonia (Alemu, 2017; Darvesh et al., 2017), it makes sense to align mortality to these convergent comorbid factors for a better understanding. As I have noted previously, one pathway for children mortality is correlated to diarrheal illnesses and the findings above also collaborate well with WHO/UNICEF suggestions and recommendations. As WHO/UNICEF pointed out,

poor water and sanitation cause about 28% of child deaths, and adequate sanitation and water sources are cost-effective and proven interventions (Alemu, 2017). About 9 in 10 incident diarrheal cases can be avoided with proper sanitation and water use. For instance, proper toilet use can drop diarrhea incidents by about 40%. Furthermore, proper sanitation can substantially reduce the main risk factors for child death, including undernutrition and pneumonia (Alemu, 2017). Therefore, the author concluded that addressing issues associated with access to sanitation is critical to minimize childhood death rates by 2/3 in childhood (Alemu, 2017).

Linkage Between the Study Results and the Proposed Conceptual Framework

I used the IBM-WASH and the health and human rights framework as the conceptual framework. Since the study used a quantitative paradigm, most specifically a cross -sectional design using secondary data, only certain variables in the proposed framework were examined amongst which include water , sanitation , hygiene, and the following confounders e.g., education, SES, mother age, child gender, place of residence and regions.

The human right approach principle is based on the fact that water and sanitation are basic needs that must be accessible to all (Neves-Silva & Heller, 2016). Based on the premise of the human rights perspective, access, provision, and affordability of these services to all people is an obligation for the state (Neves-Silva et al., 2016). In addition, the multiple levels dimension of the IBM-WaSH framework requires that any individual behavioral outcome must be considered within the broader communal and societal context in which it occurs. It presumes that improving WaSH practices may reduce

exposure to pathogens. Given the analysis of all the predictors and confounders in this study, it appeared that access to improved WaSH conditions under the study framework explained the linkage between access to WaSH and the health outcome (U5M) of the affected community (women and their children under 5). Therefore, sustainability in their development should ensure provision and accessibility to these vulnerable communities resources or means to strengthen their health outcome (Ness et al. (2009). IBM-WaSH is a synthesis of behavioral models associated with WaSH and organizes factors that influence behavior in an ecological framework (Hulland, Leontsini, Dreibelbis, et al., 2013). As Hulland et al. (2013) noted, this model encompasses three dimensions including Contextual Factors (i.e., access to water and soap), Psychosocial Factors (i.e., perceived risk of disease, disgust associated with contact with unclean objects, and pre-existing habit), and Technological Factors (i.e., related to the physical hardware storing soap and water) each of which function at five aggregate levels e.g., interpersonal/household, habitual, societal , individual, and community/structural. This perspective applied to water and sanitation situations can enhance the health of the underserved population, as well as structural changes about the social determinants of the health-illness-care process (Neves-Silva & Heller, 2016). Most specifically, the morbidity and mortality of WaSH related burden on children under 5 as indicated in this study.

This was evidenced by the result of this current study, in such a way that access to improved sanitation facilities, access to improved water sources, and hygiene practice explained the finding about the level of the strength or their influence on children's health outcome; precisely the under 5 mortalities. This current study found a

statistically significant association between access to improved sanitation, and reduction of U5M, indicating that women from households with unimproved sanitation facilities have a 22.4 % higher hazard of under-five mortality (HR:1.224, 95% CI: 1.044- 1.435). P=0.031 than counterparts from households with improved sanitation facilities.

Additionally, the likelihood of under 5 mortality is 20.5% higher (HR:1.205, 95% CI: 1.000- 1.453) among women living in households with access to unimproved water sources compared to those from households with access to improved water sources,(p=0.050). Also, women residing in a household with adequate hygiene have a 77.3% lesser risk of under 5 mortalities as compared with those living in households with inadequate hygiene (HR: 1.773,95% CI: 1.129- 2.784) (p=0.013).

Finally, I found out that the likelihood of under 5 mortality is 49.1% higher (HR: 1.491 [95% CI: 1.021- 2.178] (p=0.039) among women from households with inadequate hygiene, unimproved water source, and unimproved sanitation facilities compared to counterparts from households with adequate hygiene, improved water source, and improved sanitation facilities.

That being said ,WaSH are evidenced as risk factors for the survival of children; most specifically, those under the age of 5. Moreover, other factors including education, SES, mother age, child gender (higher proportion of male children death than female), place of residence (high proportion of deaths in the rural area), and regions (relatively lower proportions of children dying in Centre-Nord, Centre-Ouest, and Sud-Ouest) affect the under 5 survival as well. Limited or lack of access to affordable, clean, safe, and sufficient WaSH sources leads to a devastating effect on the dignity, prosperity, and

health of billions of individuals around the world. Yet, leading to substantial consequences for people to realize other human rights (United Nations Water, 2020).

Impact of Key Variables on Under-5 Mortality

Access to WaSH, Diarrheal Illnesses, and the Under-5 mortality

Given the new MDGs targets of SDGs, the interaction between improvement in children's health and non-health fields have been increasingly recognized. Hence, WaSH interventions (i.e., improvement of access to good WaSH) provide opportunities to improve the health and well-being of children through preventive actions e.g., improvement of their nutritional status and halting the transmission of communicable illnesses (Darvesh et al., 2017). Additionally, Angoua and associates explained that poor socioeconomic status, geographic settings, and rural exodus are among factors that predict access to sanitation and water. According to the authors, people residing in poor peri-urban communities in SSA cities are still challenged by access to WS.

Alemu (2017) expressed similar views regarding the differential level of access to WS sources based on geographic setting comparing several African countries. From the WHO/UNICEF (2012) assessment, progress made by Africa about access to basic sanitation is still low and limited. From 1990 - to 2010, about 35-40 % increase in access to sanitation was done (with a gain of 189 million with access) (Alemu, 2017). With the huge population growth, the urban population has doubled between 1990 to 2010, more than 1 in 4 people relies on public or shared sanitation sources in urban zones.

There is evidence about the linkage between diarrheal diseases, WaSH variables, child morbidity, and mortality. Diarrhea is still the main risk factor of mortality in children under five years old (Darvesh et al.,2017; Fotso et al., 2007). Its transmission pathways are associated with improper sanitation and lack of potable water (World Health Organization, n. d; Angoua et al., 2018; Pink, 2013); as well as poor hygiene. Previous literature has highlighted the role diarrhea plays in the life and wellbeing of children under 5. Diarrhea was classified as the main cause of mortality and morbidity in childhood (Darvesh et al., 2017; Pink, 2013). Diarrhea was evidenced as the second predictive morbid risk factor among children under 5 years old (Baker et al., 2016). The occurrence of diarrhea is linked to poor WaSH conditions. Poor WaSH techniques is the primary exposure pathway for infection most often in disadvantaged regions (Darvesh et al., 2017; Pink, 2013).

As Baker and associates noted, three-fourths million children are killed by severe dehydration associated with diarrhea occurrence. Often, diarrhea tends to induce long-term damage to the gut, malnutrition, and growth stunting (Baker et al., 2016). The enteric pathogens of diarrhea (i.e., viruses, parasites, and bacteria) are transmitted through poor hygiene and/or infected drinking food and water. As Baker and associates suggested, improving conditions in WaSH may more likely minimize risks of exposure to infectious agents and reduce incident diarrhea in childhood. For instance, about a 36 percent decline in diarrhea risk is associated with improved sources of sanitation (Baker et al., 2016). Darvest et al. (2017) shared the same views and suggested that poor WaSH status and interventions can affect children's development and growth in various ways

and are consensually acknowledged that without improving WaSH conditions, improvement in undernutrition would not be feasible for the disadvantaged children around the world (Darvesh et al., 2017).

Wealth and Socioeconomic Status (SES)

The study results showed that children from the poor households were more likely to die compared to counterparts from richer households. For instance, there were about 45.2% under 5 death rates among non-poor households compared to 54.8% death in the poorer households. These results resonate well with previous findings from Ezeh et al (2014) works, the authors noted that this can be explained by the fact that SES implies higher living standards with underlying economic power when living in such a higher social ladder. Subsequently, with more advantage to access to basic subsistence resources such as wealthier households may have improved water sources and excreta disposal facilities than poor households.

This study indicated that the economic status of a household impacts the survival of their children below 5 years old residing in the household. As Ezeh et al. pointed out, during all age periods, children from poor households had a significantly higher risk of death versus counterparts from rich households. For instance, they specifically found that there was a statistically significantly greater hazard of death for post-neonatal infants born to mothers from poor households (HR = 1.60; CI: 1.27–2.03) and middle-class households (HR = 1.46; CI: 1.18–1.80) versus infants from rich households (Ezeh et al., 2014).

Similarly, to the above, Ettarh and Kimani (2012) found that the likelihood of death among children living in the middle and highest wealth quintile was lower than those in the lowest wealth quintile in rural areas. Similar to these results, in Sierra Leone Tagoe et al.'s (2020) study found out children born in poorer households were more likely to die before reaching 5 years of age.

In contrast, these authors found that the risk of mortality in Sierra Leone's children, from the richest or richer households has not a significant impact on their survival. They explained this as the wealth gap between the poorer and poorest households which may be very significant based on the fact that children born in poorer households are more advantageous to survive. However, many studies noted that dwelling in richer households increases the odds of survival in children beyond five years old (Ezeh et al., 2015; Lartey et al., 2016; Sahu et al., 2015; Tagoe et al., 2020).

As shown both in this study and previous literature, no health factors can also influence people's health and life expectancy. According to Bezruchka (2010), increased numbers of evidence suggest that early life is an important predictor for a better health outcome in adulthood specifically, people socioeconomic and the areas where they work and live contribute to predicting their health outcomes. For instance, in the USA, level of risk in morbidity, reduced access to healthcare, mortality, unhealthy behaviors, and decreased SES conditions (CDC, 2011) are considerably associated with individual, community, and population health outcomes overall. In fact, " differences in the quality of medical care have less effect on people's life expectancy than social differences in their risks of getting some life-threatening diseases in the first place. The higher

differences in income and social distances are bigger, subsequently more important social stratification (Wilkinson, & Pickett, 2010).

Number of Household's Members

The result of the demographic variables showed that an increase in the number of household members was associated with under 5 mortality and the hazard ratio was (HR=1.080, CI:.740-1.577), with equal (P=.689 more than 0.05); so regardless of clinical significance, this is not statistically significant. These results resonate well with previous studies from Ayele et al. (2015) and Tagoe et al. (2020). As Tagoe and associates pointed out, one way to explain this relationship between these two variables may be the fact that as many people living in the house, may stretch the family resources, making it harder to feed and nurture the under 5 children context-based: hence, impacting these children's wellbeing and health.

Number of Children Under 5 in the Household

The study results showed that having one (1) under-5 child in a household increases the chance of death (HR:2.265, CI: 1.766-2.906), P=.000, as compared to a household with a mother who took care of more than two (2) under-5 children. In previous research, Tagoe et al. (2020)found that an increase in the number of children under 5 in the household and an increase in the number of a mother's living children decreases the likelihood of a child's death before age 5 . As the authors explained, mothers of living children in this context may have acquired experience and knowledge in the previous childbearing over time, and this may explain the variable (number of children under 5) protective effect on child survival (Tagoe et al., 2020).

Gender and Under-5 Mortality Among Women

In this study, results showed that the mortality in under 5 males was higher in gross as compared with females (38.4% female versus 61.6% male death). Being female reduces the risk of about 45.6% of under 5 mortality (HR: 0.544, CI: 0.426-.694), P=.000 compared to males children. In another word, males children have 45.6 increased risk of death compared to females, hence being female is protective context-based .With regards to the gender of the 5 children, several studies previously indicated that in SSA male children are more likely to die before reaching 5 as compared to the under 5 female children (Aheto, 2019; Ezeh et al., 2015; Tagoe et al., 2020; Van Malderen et al., 2019). Higher mortality rates among male children have been reported in many national surveys and studies in SSA (Ettarh & Kimani, 2012). In contrast, in Ettarh and associates' study, the risk of mortality in this same group was not significantly different in both male and female under 5 children. As Weiss et al (2010) pointed out, within the first early weeks of their lives, male children got circumcised in most African cultures. Failure to properly treat the wound around the male child's genital could predispose him to severe infections, leading to death (Tagoe et al., 2020).

Mother Age and Under-5 Mortality Among Women

In the current study, less than 29 years old women have higher death rates among their under 5 children than those mothers more than 29 years old (53.9% vs 46.1% respectively). Older mothers have a lower risk of under 5 mortalities as compared to younger mothers (HR=.544, CI: 0.426, 0.694), P= .000, this is statistically significant at 95% CI, P less than 0.05. This result is consistent with other studies including Ezeh et

al.(2014) in which, for instance, infants born to mothers under 20 years old had a 3.07 times greater risk of dying than those born to mothers aged 20 years old or more (HR = 3.07; CI: 2.42–3.90). Moreover, Ettarh et al.(2012) found out that a lower likelihood of under 5 death was associated with older mothers; however, this was significant for those ranging between 32 years and more among rural women compared with age 21 or above, among urban women.

Limitations

Despite a great deal of external validity (mainly due to the huge sample size) and power; limitations inherent to the specific design used in this study must be taken into account. One of the main limitations is the lack of temporal association in cross-sectional designs. The relationships between the study variables are only correlational (Frankfort-Nachmias et al., 2015; Szklo et al., 2014). The study also excluded other determinants of childhood morbidity and mortality previously evidenced in the literature as comorbid factors such as diarrheal diseases, respiratory diseases, and factors influencing access to health facilities. Those factors may have impacted the outcome variable: U5M among women 15-49. Another limitation in this study is the exclusion of the under 5 mortalities associated with dead mothers that could have affected the study quality (reliability and validity).

Another limitation of this cross-sectional study using the secondary data from DHS is recall bias led by inaccurate reporting of the timing of some events or the level of underreporting (Asaolu et al., 2016). Thus, restricting this analysis to the most recent

births 5 years before each survey helps minimize potential recall bias on birth and death dates reported in the survey data.

Social Change Implications

This study on under 5 mortalities among women and WaSH variables highlighted key findings on access to improved WaSH variables and their influence on under-five mortality in Cote D'Ivoire. The application of Cox was a unique dimension to the analysis of the differences in mortality below the age of 5, also an area for further research. In public health policy, programmatic, and advocacy, the assessment of the impact of water and sanitation programs could provide tangible and substantial evidence to inform decision making for planning and prevention through designing effective upstream population-based strategies to mitigate or minimize the magnitude of this vital issue among reproductive women in Cote D'Ivoire and beyond.

- The results of this study indicated that there is a statistically significant difference in the under 5 mortality associated with access to improved sanitation sources (p=0.013). This infers that those children from households using improved sanitation facilities have a lower risk of death (HR:1.224, 95% CI: 1.044- 1.435) as compared to those coming from households with unimproved sanitation facilities. In another word, women with unimproved sanitation facilities have (22.4%) higher risk of under 5 mortality compared to counterparts with improved sanitation facilities.

- The likelihood of dying (HR:1.205, 95% CI: 1.000- 1.453) is higher in children residing in households with access to unimproved water sources than those residing in households with access to improved water sources if this was statistically significant (p=0.050). Women with unimproved water sources have (20.5%) higher risk of under 5 mortality compared to counterparts with improved water sources.
- Children living in a household with adequate hygiene are 1.773 times less likely to die as compared with those living in households with inadequate hygiene (HR: 1.773,95% CI: 1.129- 2.784) (p=0.013). Women with inadequate hygiene have (77.3 %) higher risk of under 5 mortality compared to counterparts with adequate hygiene.
- The likelihood of mortality is 1.491 time (HR: 1.491 [95% CI: 1.021- 2.178] (p=0.039) less in children residing in households with adequate hygiene, improved water source, and improved sanitation facilities compared to counterparts living in households with inadequate hygiene, unimproved water source and unimproved sanitation facilities. In another word, women with unimproved WaSH have (49.1%) a higher risk of under 5 mortality compared to counterparts with improved WaSH.

This result can guide program planners, public health practitioners, researchers, and funders at the national and subnational levels for women empowerment, promote the need to provide and ensure WaSH for these communities, especially women and their children. This is aligned with the new MDGs targets of SDGs, as Darvesh et al. (2017)

stretched out, the interaction between improvement in children's health and non-health fields was increasingly recognized. Yet, WaSH interventions (e.g., improvement of access to good WaSH) provide opportunities to improve the health and well-being of children through preventive actions e.g., improvement of their nutritional status and halting the transmission of communicable illnesses

In addition, this study could guide and be used to advocate for more resources for targeted programs and help the affected communities in Cote D'Ivoire and beyond. From an epidemiological standpoint, the examination of multiple risk factors associated with child mortality in this cross-sectional study, could provide more insight into the multifactorial determinants of child mortality. As well as to guide for prioritization and prevention measures for the population at risk to empower them e.g., improve well-being, reduce related morbidity, and mortality of the priority population. The potential social change implication includes the use of health education and promotion to sensitize the local community to adopt preventive behaviors (i.e., proper hygiene attitude; provide education programs; promote the availability and access to clean water; and proper sanitation facilities). As mentioned before, all this would gradually impact the community's well-being, quality of life, and life expectancy overall. From a programmatic standpoint, insights from this study may guide and frame prospective program planning, prevention, advocacy, and resources allocation (Parker, & Thorson, 2009; Resnick et al., 2013).

Globally, one contribution pertaining to this research study is to help to achieve the United Nations recommendations for the SDGs, which is to ensure healthy lives and

children's well-being. For instance, the “goal 3 target 3.2” is to stop preventable death in children (i.e., less than five years and newborns) by 2030 (Adebowale et al., 2017). Hence, the reduction of under-five mortality below 25 in 1,000 live births. Also, enhance the sanitation and drinking water target 7C: “to halve the proportion of the population with no sustainable access to safe drinking water and basic sanitation (Bartram et al. 2014, p. 2). Moreover, to ensure the achievement of the SDA's new goals and recommendations for 2030.

Conclusion and Recommendations

Despite remarkable progress in child survival since 1990, the global burden of the under-five mortality rate (U5MR) remains immense . U5MR has declined to 39 from 50 percent per 1,000 live births (UN IGME & UN MMEIG, 2019). Despite remarkable progress in child survival overall, huge disparities still appear between regions. SSA still lags behind expectations for instance in 2018, more than 82 % of the global burden of mortality among children under five live in Sub-Saharan Africa (54 percent) and South Asia (28 percent) (UN IGME & UN MMEIG, 2019). According to the World Health Organization, about 5.2 million children below five died in 2019, with 14,000 dying each day. Cote d'Ivoire is still lagging behind expectations with 79 per 1000 live births in 2019 rather than 25 and below.

The lack or limited WaSH quality and access expose a million children to illnesses associated with WaSH and subsequently lead to preventable death. Daily, about 800 and more childhood deaths were attributed to preventable illnesses associated with

poor WaSH (UNICEF, 2019 b). Many of these children die each day from diarrhea and other illnesses led by lack and/or improper sanitation and water sources (UNICEF Côte D'Ivoire, n. d). Understanding how WaSH influences childhood health (i.e., U5MR) is critical to minimize its burden; hence, reducing case-specific morbidity and mortality among these children.

This quantitative correlational analytical cross-sectional research aimed to better understand the risk exposure faced by women in Cote D'Ivoire and its linkage to the U5MR. The overall goal of this study was to specifically examine the magnitude of the relationship between access to improved WaSH and the U5MR among women 15-49 in Cote D'Ivoire using all available and relevant Cote D'Ivoire DHS data from 2005-2020.

This research tried to uncover the extent to which water, sanitation, and hygiene affect mortality in this age group. One importance of this research was that despite the MDGs recommendations that all countries should reduce their U5MR to no more than 25 per 1,000 live births (WHO, 2018), Cote D'Ivoire still lag behind the expected target of 25 per 1000 live births, with a high U5MR of 92 per 1000 live birth in 2016 (The World Bank Group, 2018) and 81 per 1000 live birth in 2018 (The World Bank Group, 2019). I used IBM-WASH and the health and human rights framework as the conceptual framework. The findings using survival analysis showed that:

- The results of this study showed that women from households with unimproved sanitation facilities have a 22.4 % higher hazard of under 5 mortality (HR:1.224, 95% CI: 1.044- 1.435). P=0.031 than counterparts from households with improved sanitation facilities.

- The likelihood of under 5 mortality is 20.5% higher (HR:1.205, 95% CI: 1.000-1.453) among women living in households with access to unimproved water sources compared to those from households with access to improved water sources,(p=0.050).
- Women living in a household with adequate hygiene have a 77.3% lesser risk of under 5 mortality as compared with those living in households with inadequate hygiene (HR: 1.773,95% CI: 1.129- 2.784) (p=0.013).
- The likelihood of under 5 mortality is 49.1% higher (HR: 1.491 [95% CI: 1.021-2.178] (p=0.039) among women from households with inadequate hygiene, unimproved water source, and unimproved sanitation facilities compared to counterparts from households with adequate hygiene, improved water source, and improved sanitation facilities.

Water, sanitation, and hygiene are evidenced as risk factors for the survival of children; most specifically, those under the age of 5. Besides WaSH variables, the following factors impact children survival e.g., education, SES, mother age, child gender (higher proportion of male children death than female), place of residence (high proportion of deaths in the rural area), and regions (relatively lower proportions of children dying in Centre-Nord, Centre-Ouest, and Sud-Ouest). Mortality among children below 5 is still a priority public health problem therefore, appropriate public health measures are key to tackling this issue. The current research provided insights about the magnitude of WaSH and other determinants that influence U5M in Cote D'Ivoire. This information can be used in many ways including in health policy, in public health

program design, and implementation for women empowerment; hence, to increase the odds for children's survival. Empowering women through employment will positively impact their overall well-being, health, and life expectancy for both women and their children under 5 and beyond.

As the global efforts focus on reducing under 5 mortality by 25% per 1,000 live births under SDG; such efforts may lead to a healthy population and reduction of mortality in children under 5 in both Cote D'Ivoire and beyond. This study may lead to positive social changes with a better understanding of how WaSH influences U5MR in Cote D'Ivoire. Furthermore, by providing program planners, public health practitioners, and governmental agencies important insights on how to create targeted and effective strategies and programs to tackle the problems the priority population faces. For instance, to promote ongoing hygiene education in households and communities for a greater impact on children's health (Diouf et al., 2014). As well as to ensure and provide quality WaSH to vulnerable communities.

Exploring various risk factors for under 5 mortality among women in this study provides more insight into the related literature. It can also guide prioritization, prevention activities, and measures for the population at risk to empower them e.g., improve well-being, reduce related morbidity, and mortality of the target population. One potential social change implication suggestion is the use of health education and promotion to sensitize the local community to adopt preventive behaviors (i.e., proper hygiene attitude; provide education programs; promote availability and access to clean water; and proper sanitation facilities).

Given the multidimensional nature of this public health issue and its link with underlying factors led by various disparities and inequalities such as the inequality in the distribution of the under 5 mortality and beyond. I therefore, suggest that further research be designed to look at the broader perspective, not only looking at the underlying determinants of this public health, but also using this lens, taking into account various health predictors to design the most effective approach and interventions to tackle health inequality (Gehlert, et al., 2008) associated with child survival.

A societal approach is imminent for a broader transformation in human society through the reduction of inequality to increase fairness, social justice, and equity (Gostin, 2008). Similarly, to Dankwa-Mullan et al.(2010) worldview as he stretched out, to improve population health outcomes, additional efforts are required to tackle health disparities through the use of evidence-based data /statistics to guide leadership, policy, and decision-makers about housing, income, employment, education, and environment; all of which impact an individual's expectation and perspective with regards to health and health care system. Sharing best practice models and collaboration efforts must continue through partnerships that can enable the development of research, measures, interventions, tools, strategies, policies, and institutional shifts that would directly alter health outcomes among vulnerable communities/populations including Cote D'Ivoire's reproductive women, their children, and beyond.

As Koh (2009) pointed out, the power to address problems often lies "well beyond the control of any single authority. Rather, sustainable solutions often demand broad societal level changes, requiring input, not just from health experts, but also

economists, ethicists, and policymakers among others. As well as stakeholders from advocacy groups, philanthropies, private companies, government agencies, religious leaders, and non-government organizations (Koh, 2009). According to Wilkinson et al. (2010), the failure in policy, leadership, and system thinking are because leadership tackles issues in a restrictive way, an isolating problem, yet many of the problems are interconnected in a dynamic not always apparent fashion.

From the above, taking into account the underlying factors that cause disparities at all levels, including physical, mental, social, and environmental, are essential earlier as life begins; hence, doing so could induce greater upstream health benefits (Wilkinson, & Pickett, 2010). Therefore, to address these disparities and achieve equity of health for the population (i.e., specifically the issue with U5M), a combination of multiple elements must be considered, including effective leadership at all levels, organizational structure, economic status, and education. That embraces the powerful integration of science, practice, and policy to create lasting change (Koh, & Nowinski, 2010). The linkage between the system thinking approach provides relevant evidence of the interconnectedness of all systems to social outcomes and health.

As Best and Holmes (2010) pointed out, to leverage a system thinking "outside the box" is through leadership study, so that insight from this study could be translated into practice and policies to enable manifest, meaningful, and positive social changes. The need for effective public health leadership for the affected community is imperative. Hence, through a comprehensive, collaborative, and the right system thinking and

leadership approach, this issue could be addressed more effectively. Given the above and from the findings already discussed earlier, I recommend the following:

1. I suggest the use of mixed methodology with both a qualitative approach blended with a quantitative paradigm such as quasi-experimental, case-control, or cross-sectional to further explore other factors besides those already examined in the current study e. g., leadership approach; system thinking; leadership theories, and perspectives; environmental factors; behavioral factors; laws, regulations, and policy; and their influence and effectiveness on the population health outcomes, including the under-five survival.
2. I suggest an integrated, comprehensive, and ecological framework via a multilevel, multisystem, multiagency, transdisciplinary, and collaborative means to tackle this issue at various levels of intervention (i.e., the individual, the policy, and the community levels).
3. This framework must be an ecological model using upstream, ecological, and preventive (i.e., primordial, primary, and secondary) approach through novel system thinking and structural changes to prevent and minimize health inequality (precisely the unequal distribution of U5M among women in the community).

As aforementioned, the result of the current study can guide program planners, public health practitioners, researchers, and funders at the national and subnational level for women empowerment, promote the need to provide, and ensure WaSH for the

affected communities, women, and their children. This resonates well with the new MDGs targets of SDGs, according to Darvesh et al. (2017), the interaction between improvement in children's health and non-health fields was increasingly acknowledged Hence, WaSH programs and interventions (i.e., improvement of access to good WaSH) can provide opportunities to enhance the health and well-being of children through preventive actions including improvement of their nutritional status and halting the transmission of communicable diseases, and associated mortality. Conclusively, insights from the current study as well as the proposed studies and recommendations could inform decision-making for further planning and design of effective upstream population-based strategies to alleviate the health burden of the local population in Cote D'Ivoire and beyond.

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