Investigating Water Interruptions, Household Improvement of Drinking Water, and Diarrhoea among Children Under-Five in South Africa

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DECLARATION

I, Rika Umra, declare that:

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2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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ABSTRACT

Diarrhoeal disease is one of the leading causes of death among children under five (WHO, 2019). The purpose of this study was to investigate the factors associated with diarrhoea in children under five, particularly household water interruptions and the household water treatment (HHWT). The first objective of this study was to investigate the association between water interruptions, HHWT, environmental (toilet facilities and source of drinking water), personal illness control (disposal of stools and handwashing), socioeconomic (education, occupation, and wealth) and demographic (maternal age, marital status and place of residence) factors; and diarrhoea among children under five. The second objective was to investigate socioeconomic and demographic factors associated with HHWT.

The study is quantitative in nature. A secondary data analysis of the South Africa Demographic and Health Survey 2016 was conducted, this was the third Demographic and Health Survey to be conducted in South Africa (NDoH, Stats SA, SAMRC & ICF, 2017). The survey consisted of a nationally representative sample of approximately 15 000 selected dwelling units (NDoH et al., 2017). Of the 13 000 occupied households, data was collected in face-to-face interviews by trained interviewers from 11 000 households (NDoH et al., 2017).

The results of the study revealed that water interruptions (AOR 2.14, 95% CI: 1.48-3.09) and mother living with a partner (AOR 1.58, 95% CI: 1.06-2.34) were significant predictors of diarrhoea among children under five. The results also revealed that maternal occupation, specifically clerical (AOR 1.93, 95% CI: 1.04-3.57) and services (AOR 3.12, 95% CI: 1.82-5.33) were significant predictors of employing any water treatment at a household level.

In order to reduce diarrhoeal disease among children under five and subsequently child mortality, water interruptions need to be reduced to an absolute minimum and household water treatment needs to be more widely employed alongside better water handling and storage practices. In addition, more people need to be educated on the importance of ensuring that water is clean and safe prior to consumption.

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ABBREVIATIONS AND ACRONYMS

AOR	Adjusted Odds Ratios
CI	Confidence Interval
DHS	Demographic and Health Survey
DoH	Department of Health
DUs	Dwelling Units
E. coli	Escherichia coli
EAs	Enumeration Areas
EPEC	Enteropathogenic Escherichia Coli
ETEC	Enterotoxigenic Escherichia Coli
HHWT	Household water treatment
MDG	Millennium Development Goal
MSF	Master Sampling Frame
POU	Point-of-Use
PPS	Probability Proportional to Size
PSUs	Primary Sampling Units
SSA	Sub-Saharan Africa
StatsSA	Statistics South Africa
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION

1.1) Background of the Study

Globally, sub-Saharan Africa has been shown to have the highest child mortality rate, but, in addition to this, it has also proven to have the largest absolute decline in child mortality over the past twenty years (United Nations, 2015). Nevertheless, "developing countries or economically disadvantaged regions carried the highest burden of under-five mortality, with nearly four fifths of all under-five mortality occurring in Sub-Saharan Africa and south Asia" (Alebel, Tesema, Temesgen, Gebrie, Petrucka, & Kibret, 2018:2). Awotiwon, Pillay-van Wyk, Dhansay, Day, & Bradshaw (2016:1060), state that "In Africa, an estimated 696 million cases and 9.6 million severe episodes of diarrhoea occur among children", with diarrhoea estimated to account for 19% of deaths of under fives in South Africa and for 46% on the African continent" (Awotiwon et al., 2016:1060). According to Bamford, Barron, Kauchali & Dlamini (2018:33), "Data from the Second National Burden of Disease Study" show that in South Africa, diarrhoea accounted for "16%" of under-five child mortality (Bamford et al., 2018:33). "The 2010 General Household Survey (GHS), a nationally representative inquiry into the livelihood of South Africans, showed that there were over 60,000 cases of childhood diarrhoea per month and approximately 9,000 child diarrhoeal deaths in the same year" (Chola, Michalow, Tugendhaft, & Hofman, 2015:2)

Goal four, of the Millennium Development Goals, was to reduce child mortality (United Nations, 2015; Walker, Rudan, Liu, Nair, Theodoratou, Bhutta, O'Brien, Campbell & Black, 2013). More specifically, the target of this goal was to reduce the under-five mortality rate, by two-thirds to 20 deaths per 1000 live births, between 1990 and 2015 (Statistics South Africa, 2015). In South Africa, there was a significant and steady decline in the under-five mortality rate over this period, but not enough to meet the 2015 goal of reducing the under-five mortality rate to 20 deaths per 1000 live births (Statistics South Africa, 2015). "The under-five mortality rate estimated from data in the country's Vital Registration System declined from 38 deaths per 1 000 live births in 1998 to 34.3 per 1 000 in 2013" (Statistics South Africa, 2015:1). It is important to understand the causes of child mortality in order to reduce it. According to Statistics South Africa (2015:2), "the leading and preventable causes of death among children 12 to 59 months include malnutrition, diarrhoeal disease, lower respiratory tract infections such as pneumonia and perinatally acquired HIV infection" (Statistics South Africa, 2015:2). Taking a closer look at this, in developing countries, the leading cause of death, disability and ill-health, among children under the age of five, remains to be diarrhoea (Awotiwon et al., 2016). "Diarrhoea accounts for 19% of deaths of under fives in South Africa and for 46% on the African continent" (Awotiwon et al., 2016:1060).

"Childhood diarrhea is defined as the passage of three or more loose or watery stools per 24 hours or an increase in stool frequency or liquidity that is considered abnormal by the mother (Alebel et al., 2018:2). Diarrhoeal disease remains to be the leading cause of child morbidity and mortality, in spite of the noteworthy progress made in reducing under-five child mortality. Approximately fifteen percent of total under-five child deaths that occur yearly is caused by diarrhoeal disease, this many seem like a small percent, however, it equates to "approximately 2.5 million" child deaths per year (Alebel et al., 2018:2). This places diarrhoeal disease as second on the ranking of child death causes. Diarrheal diseases are communicable, this means that they can be transferred from one person to the next. They are caused by pathogens that are transferred or transmitted via various vehicles (Arvelo, Kim, Creeek, Legwaila, Puhr, Johnston, Masunge, Davis, Mintz, & Bowen, 2010). According to Arvelo et al. (2010:1002), "Persons living in developing countries with poor access to safe water, sanitation or hygiene infrastructure have increased risk of exposure to viral, bacterial and parasitic pathogens that can cause diarrheal diseases" (Arvelo et al., 2010:1002).

There is a great difference between the under-five mortality in developed and developing countries. "In developing countries, child mortality accounts for a relatively higher proportion of all deaths, whereas in the developed countries, it represents an increasingly small segment of total mortality" (Oloo, 2005:1). The rates in developing countries are over seven times worse than the under-five mortality rates in developed countries. According to Ogada (2012), the difference goes from "a high of 180 per 1000 live births in Angola to only 2.31 per 1000 live births in Singapore" (Ogada, 2012:1). "According to World Health Organization (WHO) data from 2016, the under-five mortality rate in low-income countries was 73.1 deaths per 1000 live births, nearly 14 times the average rate in high-income countries (i.e., 5.3 deaths per 1000 live births)" (Alebel et al., 2018:2). According to Lechtenfeld. (2012:25), "Despite millions spent on piped water supply in developing countries, water at point-of-use is often polluted and causes increased levels of diarrhea and child mortality" (Lechtenfeld, 2012:25)

Understanding the main drivers of diarrheal diseases and how the disease spreads is vital in combating it, and in turn, further reducing child mortality. “Safer drinking water could prevent 1.4 million child deaths from diarrhoea and 860 000 child deaths from malnutrition annually” (Zin et al., 2013:6). In low-income settings, where people do not have access to purified piped water or where people are subject to frequent water interruptions, water can be treated at the “point-of-use” (Clasen, Alexander, Sinclair, Boisson, Peletz, Chang, Majorin, & Cairncross, 2015). At a household level, people can treat water by filtration, chlorination, solar disinfection, flocculation and by boiling the water (Clasen et al., 2015). In a systematic review of the literature it was concluded that there was a reduction of reported diarrhoea when households employed strategies to improve water, although, there was no significant difference in the reduction in risk between the various methods utilised by households to improve water (Clasen et al., 2015).

1.2) Rationale

The water services in South Africa has proven to be less than reliable due to the increase in the number of days South Africa’s municipal water supplies to households are interrupted. In an in-depth analysis of the Community Survey 2016 data, 23.4% of households in South Africa that had experienced some water interruptions in the three months before the study (Statistics South Africa, 2017). The Cape Town Water crisis (2016-2018) had occurred due to a drought that had resulted from extremely low rainfall, which consequently led to less water in the dams. As a result of this, many people were left without water or very little water due to the water restrictions that had been put in place by the City of Cape Town, in order to conserve the little water available in the province. “Day Zero” was a term used by the City to indicate the day on which “water would be turned off in neighbourhoods if the dams reached 13.5% full, which would require citizens to fetch a daily 25 litre per person allocation at public Points of Distribution (PODs)” (Ziervogel, 2019:8).

In fear of day zero, many businesses and individuals began to seek alternative water supplies. Water was collected by many locals from natural springs and mountain streams around the city. The lack of water, or the collection of water from alternative, unsafe sources has health implications. A lack of water leads to a reduction in handwashing which increases the risk and spread of faecal-oral contamination (Said-Moorhouse & Mezzofiore, 2018). In addition to this, the collection and consumption of water from unsafe water sources without treating or purifying the water can lead to diarrhoeal diseases (Geremew et al., 2018). Research has shown that households can reduce diarrhoea by taking various steps to treat water (Geremew et al., 2018). What is important is that households have the knowledge surrounding the importance of treating water before consumption and that households are aware of the various ways in which to treat water at a household (point-of-use) level. Therefore, this health promoting behaviour has become increasingly important in light of the growing number of days that South Africa's municipal water supplies to households are interrupted.

1.3) Aim

To determine and investigate the factors associated with diarrhoea in children under five, particularly household water interruptions and the household improvement of drinking water.

1.4) Objectives

The objectives of this research are:

1) To investigate the association of water interruptions with reported diarrhoea in children under five in the household.
2) To investigate the association of household water treatment with reported diarrhoea in children under five in the household
3) To investigate the environmental and personal illness control factors associated with diarrhoea in children under five.
4) To investigate the socioeconomic and demographic factors associated with diarrhoea in children under five.
5) To investigate the socioeconomic and demographic factors associated with household water treatment.

1.5) Questions to be asked

1) Is there a significantly higher prevalence of reported diarrhoea in children under five years of age in households reporting water interruptions?
2) Is there a significantly lower prevalence of reported diarrhoea in children under five years of age in households reporting water treatment?
3) What environmental and personal illness control factors are associated with reported diarrhoea in children under five diarrhoea?

4) What are the socioeconomic and demographic factors associated with reported diarrhoea in children under five diarrhoea?
5) What are the socioeconomic and demographic factors associated with household water treatments?

1.6) Null hypotheses

There was no significant difference in reported diarrhoea in children under five resident in households experiencing water interruptions and those resident in households without water interruptions.

There was no significant difference in reported diarrhoea in children under five between those resident in households where water is treated and those resident in households without water treatment strategies.

There was no significant difference in reported diarrhoea in children under five and environmental and personal illness control factors

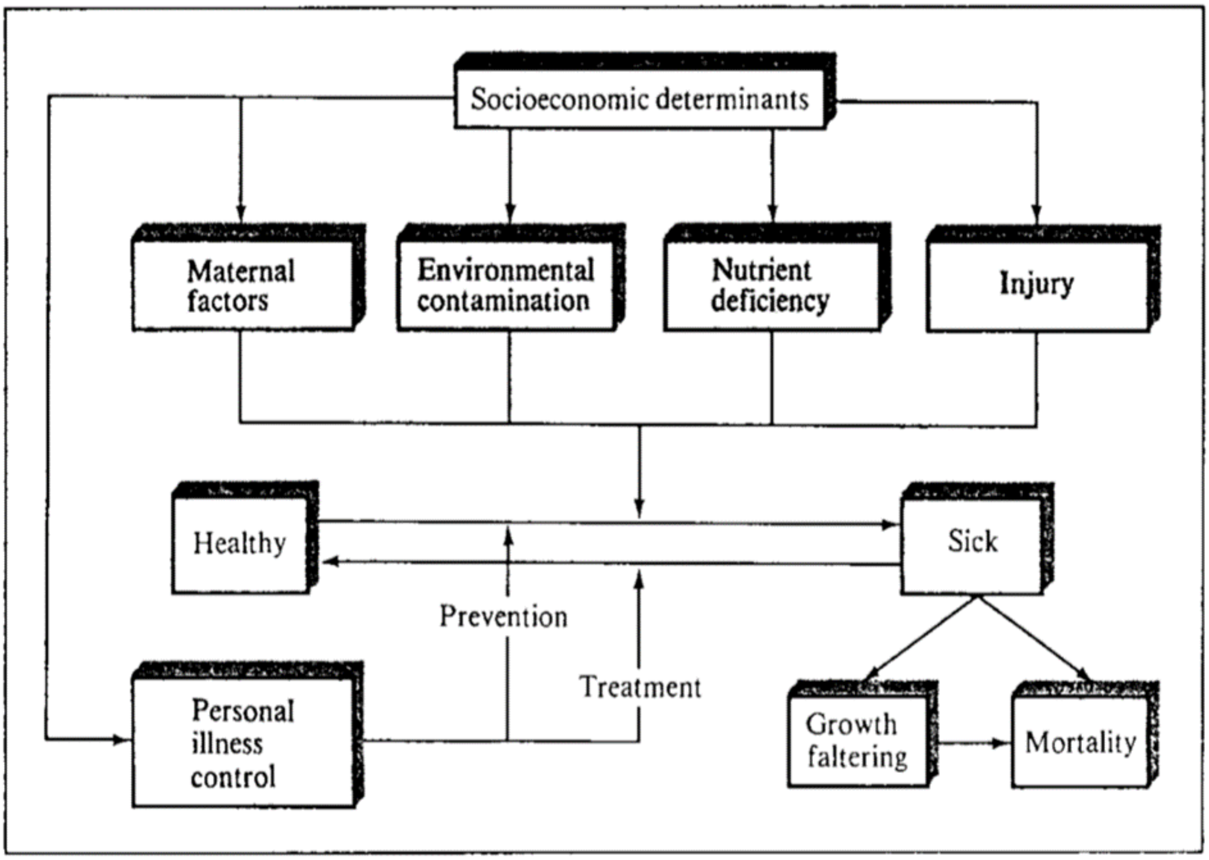
There was no significant difference in reported diarrhoea in children under five and socioeconomic and demographic factors.

There was no significant difference in household water treatment and socioeconomic and demographic factors.

1.7) Theoretical Framework

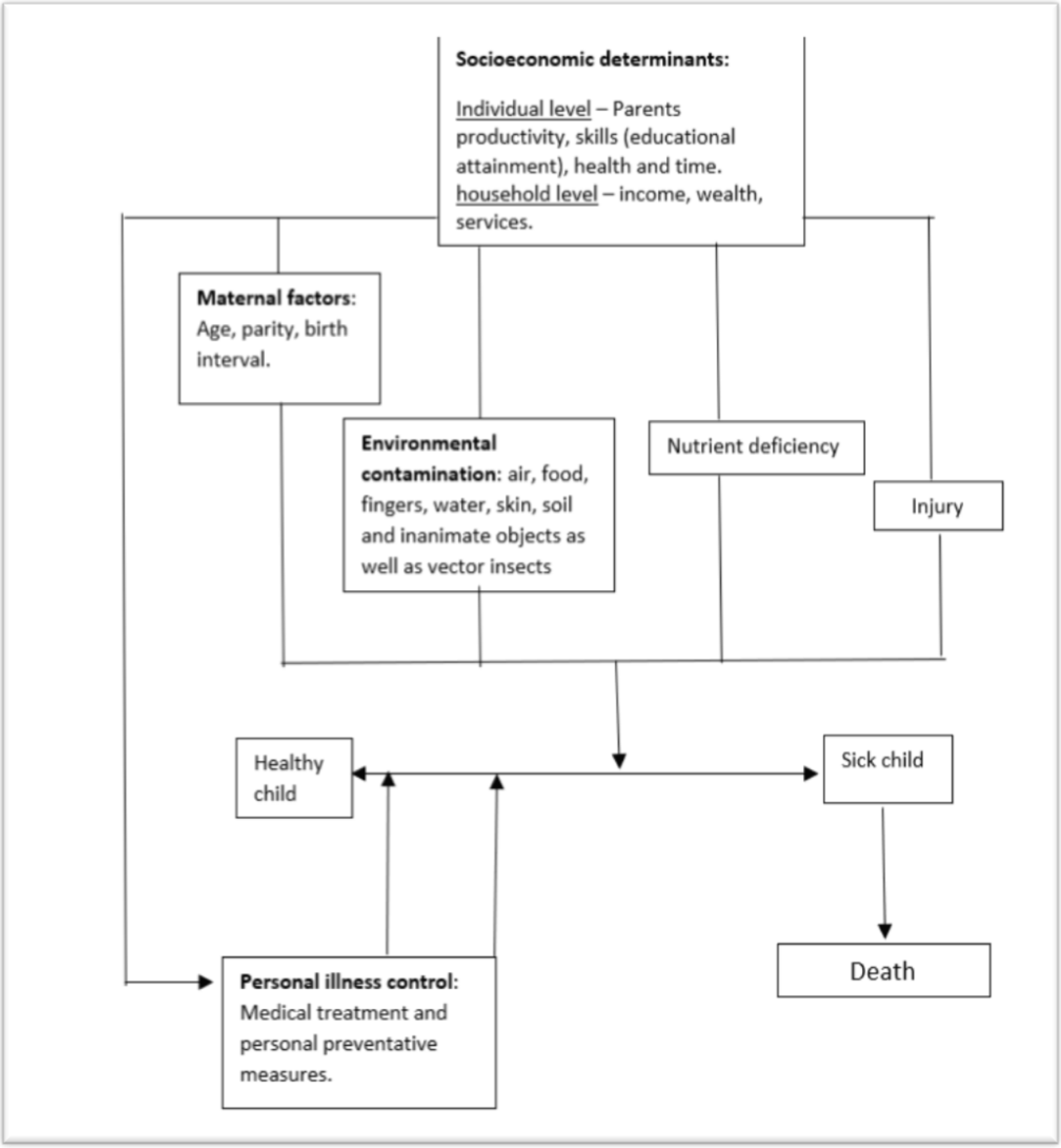
For the study of child survival in developing countries, Mosley and Chen (1984) had developed an analytical framework. This framework distinguishes between the socio-economic and proximate determinants of child mortality (Mosley & Chen, 1984). According to Mosley and Chen (1984), the conceptual core of the framework was that social and economic determinants or distal determinants of child mortality have to operate indirectly through proximate determinants (intermediate variables) or biological mechanisms to influence the risk of mortality (Mosely & Chen, 1984; Ogada, 2012). Proximate determinants or intermediate variables are those determinants the directly affect child mortality risk. Proximate determinants include environmental contamination which relates to the air, food, fingers, water, skin, soil and inanimate objects as well as vector insects; maternal factors relating to maternal age, parity and birth interval; and personal illness control which relates to medical treatment and personal preventative measures (Hill, 2003). For this research, proximate determinants that will be focused on include the variables that indicate potential environmental contamination factors such as the household source of water and toilet facilities; maternal factors such as age; and personal illness control factors such as handwashing and safe disposal of stools.

In contrast to the proximate determinants, there are distal or socio-economic determinants (independent variables) of child mortality, which have to operate through the proximate determinants in order to affect child mortality. In other words, socio-economic determinants indirectly affect child mortality. These determinants are categorised into three variables, namely; individual level, household level and community level variables. For this research, the distal determinants that will be focused on is the individual level variables and the household level variables. Individual level variables include the productivity of fathers and mothers, their skills which is usually measured by formal educational attainment, their health status and the time available for child care. The impact or influence mothers and fathers have on child care is very different as child care remains the task of the mother in many sub-Saharan African countries with the impact of fathers argued to be mainly though their contribution to household wealth (Ogada, 2012). However, for mothers their educational attainment affects child mortality as it influences the choices that are made with regard child nutrition, preventive care, disease treatment and hygiene (Ogada, 2012). In addition to this, the mother's time is important in order to carry out specific parenting tasks such cleaning of the child and its clothing, preparing meals, cleaning the environment in which the child lives and nursing the child when he/she falls ill (Ogada, 2012). Household level variables include income and wealth and its effects on available goods in homestead, services that can be accessed by the family and household level assets. Household wealth can also impact individual level variables such as time.



Adapted from Mosely & Chen (1984).

Figure 1: Analytical Framework for the Study of Child Survival (Mosley & Chen, 1984)



Adapted from Mosley & Chen (1984).

Figure 2: Analytical Framework for the Study of Child Survival Highlighting Determinants for this Research.

The above framework is a visual representation of the aforementioned, a set of proximate or intermediate determinants are identified which directly influences the risk of mortality. The framework also identifies that all social and economic determinants must operate through these proximate determinants in order to affect child survival (Ogada, 2012; Mosley & Chen, 1984). The purpose of this analytical framework in this study is to provide a better understanding of the various factors which play a role in a family's production of healthy (or unhealthy) children, focusing mainly on child mortality as a result of diarrhoea. The need for this is to identify the knowledge gaps and shortfalls in childcare at different household levels.

1.8) Structure of the Dissertation

Chapter two presents a review of literature on child mortality, diarrhoea and point-of-use/ household water treatment. Chapter three focuses on the research methodology, the data set used, description of variables and analysis techniques employed, ethical considerations, as well as the validity, reliability and rigour of the study of the study are included. Chapter four provides the results of the research. Chapter five provides a discussion of the research findings and concludes by providing a summary of the research, limitations and possible future recommendations

CHAPTER 2

LITERATURE REVIEW

2.1) Introduction

In 2012, diarrhoeal disease caused an estimated 1.4 million deaths and is recognised in low income or developing countries as the third leading cause of mortality (Clasen et al., 2015). "Young children are especially vulnerable, with diarrhoea accounting for more than a quarter of all deaths in children aged under five years in Africa and Southeast Asia" (Clasen et al., 2015:6). This chapter presents the literature relating to diarrhoeal diseases and water supply interruptions. Various HHWT strategies as one of the personal illness control strategies were then reviewed. Other environmental factors (related to sanitation and the source of water), followed by other personal illness control factors (such as handwashing and stool disposal) are reviewed. Socio-economic and demographic factors associated with household water treatment diarrhoea and chid mortality are then presented. However, it must be noted that after extensively utilizing search engines such as PubMed and Google Scholar, the researcher has found that a paucity of studies related to household water treatment and specific socio-economic (mother's occupation), and demographic (maternal age and parity, marital status) factors. This indicates that there may be a gap in the research of household water treatment.

2.2) Diarrhoea in Children Under Five and Water Supply in the Household

Each year, approximately 525 000 children die as a result of diarrhoea. The World Health Organisation defines diarrhoea as "the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual" (WHO, 2019). The disease can last a few hours or several days, leaving the body without the necessary salts and water required to survive. The causes of diarrhoeal deaths have changed over time, previously severe loss of bodily fluids and dehydration were the primary causes of diarrhoeal deaths, however, recently causes have expanded to "septic bacterial infections" which has caused the proportion of diarrhoeal-related deaths to increase (WHO, 2019). Those that are most at risk of being severely affected by the disease, to a point at which it becomes life-threatening are people living with HIV, malnourished children and children with impaired immunity (WHO, 2019).

Diarrhoeal disease is primarily caused by the transmission of viral, protozoan and bacterial pathogens. This transmission usually occurs via a "faecal-oral route", this happens when food and water that is contaminated by faeces, is consumed (Clasen et al., 2015). There are different types of pathogens which exist, and which vary according to seasons, settings and population groups (Clasen et al., 2015). The most important of the pathogens are *Cryptosporidium sp., Giardia lamblia, rotavirus, Escherichia coli, Shigella sp., Salmonella sp., Entamoeba histolytica, Vibrio cholerae, Campylobacter jejuni* and *norovirus* (Clasen et al., 2015:6). Out of the ten pathogens listed, in low-income, developing countries, *Rotavirus* and *Escherichia coli*, remain to be the two most common etiological agents of moderate-to-severe diarrhoea (WHO, 2019). In developing countries, death as a result of diarrhoeal disease is commonly attributed to inadequate or poor sanitation, hygiene and water (Geremew, Mengistie, Mellor, Lantagne, Alemayehu & Sahilu, 2018). In a study conducted in a rural community in Kenya by Othero, Orago, Groenewegen, Kaseje, & Otengah (2008), it was found that 87.1% of those that participated in the study "reported that their children had suffered from diarrhea within the last 2 weeks before commencement of the study", revealing that 48% of child deaths in the study area can be attributed to diarrhoea with one of the major causes of diarrhoea being "unclean water" (Othero et al., 2008:143).

One of the most effective and efficient solutions to diarrhoea and other waterborne diseases would be to provide disinfected, safe, piped water to all households. However, this would require infrastructure of such magnitude it would "require an investment of tens of billions of dollars" every year, which developing countries would not be able to obtain (Zin et al., 2013). The developing world is home to approximately ninety percent of the total rural population, and fifty percent of the total urban population, however, most of the developing world remains without the infrastructure required for sufficiently supplying water in a conventional manner (Zin et al., 2013). "It has been reported that developing countries will need US$42 billion for new coverage in water supply and US$ 322 billion for maintaining existing water supply services" (Zin et al., 2013:7).

Consequently, according to Clasen et al (2015:6), "An estimated 1.1 billion people worldwide rely on water supplies that are at high risk of faecal contamination", meaning that almost fifty percent of the world's population faces an insufficiency of household water connections and are at risk of unsafe water due to impurities when being collected, stored, and used at home (Clasen et al., 2015). In addition to this, those that receive piped water are at risk of water interruptions, as a result of unreliable and intermittent supply services (Zin et al., 2013). According to Zin et al., (2013:7) "This situation is most acute in Bangladesh, India and Nepal, which each have an average continuity of service of less than 10 hours a day compared with 22 hours in Latin America and in the Caribbean" (Zin et al., 2013:7)

2.3) Water Supply Interruptions and Diarrhoea

Water supply interruptions are experienced by, not less than, 309 000 000 people globally (Adane, Mengistie, Medhin, Kloos & Mulat, 2017). There are various issues associated with water supplies that are intermittent as a result of interruptions. For one, the constant water supply interruptions experienced by many people worldwide, force them to store water (Feleke, Medhin, Kloos, Gangathulasi, & Asrat, 2018). According to Adane et al. (2017:2), "Intermittent water supplies transmit waterborne pathogens, increase household water storage times, and jeopardize hygiene practices" (Adane et al., 2017:2). In addition to this, the use of unsanitary or dirty cups, hands and other ways in which water is collected from water storage containers that are wide-mouthed or do not have a pouring nozzle, exposes the treated water to contamination. in many cases, intermittent water supplies or interruptions of water supplies are a result of "low quantity of water from piped sources and from leaking of the distribution systems" (Adane et al, 2017:14).

In developing countries, Enteropathogenic Escherichia Coli (EPEC) is one if the leading causes of diarrhoea among babies and children (Trabulsi, Keller & Gomest, 2002). More generally, the presence of E.coli in water, indicates faecal contamination of the water, thereby causing diarrhoea upon consumption (Adane et al., 2017). A reduction of waterborne illnesses has been noted in settings where continuous or minimally interrupted, piped water supplies have been implemented. As a result of intermittent water supplies, stored water is found to have a reduced microbiological quality which is associated with acute diarrhoea. Reasons for this are related to the irregular cleaning of water storage containers. According to Adane et al. (2017:14) "Higher E.coli contamination in household stored water more than of piped water at the household point of contact, might be due to a lack of washing of water storage containers" (Adane et al., 2017:14).

In a study, Adane et al. (2017), found that in Ethiopia, Addis Ababa is faced with the ongoing issue of water interruptions, specifically in the slums. Additionally, a study conducted in a slum located in Brazil revealed that as a result of intermittent water supplies, there was a strong link between contaminated stored water and the transmission of diarrhoea. According to Adane et al. (2017:2), "A recent systematic review revealed one study that reported a 73.0% reduction in diarrhoea after the change from intermittent to continuous water supplies" (Adane et al., 2017:2). In addition to this Hunter, Chalmers, Hughes & Syed, (2005) conducted a study on "self-reported diarrhoea in a control group" and found that there "was a very strong association between self-reported diarrhoea and reported low water pressure at the faucet" as a result of consuming possibly contaminated water, owing to a "burst water main or other loss of pressure in the distribution system" (Hunter et al., 2005:33).

In a study conducted by Huntera, Zmirou-Navier & Hartemann (2009), it was found that even when a population is being provided with clean drinking water, if the water supply is interrupted, even for a minimal amount of time, people tend to return to consuming "raw water", subsequently exposing them to the risk of infection by waterborne pathogens. "Drinking water is a major transmission pathway for ETEC, therefore, even a few days of interrupted supply of drinking water may be sufficient to destroy the health benefit from the provision of clean drinking water" (Huntera et al., 2009:2623). In addition, Huntera et al. (2009:2623) state that "the value of treated water supplies will be largely to delay the age of first infection. It is the under 12 month age group that is most likely to die from a diarrhoeal disease and so postponing the age of first infection even by a few months can substantially reduce childhood mortality" (Huntera et al., 2009:2623).

Yassin, Abu Amr & Al-Naiar (2006) conducted a study on the quality of water and human health in the Gaza Governorate, Gaza strip. It was found that due to the exponentially growing population, the demand for water exceeded supply as there was a "shortage in water resources", forcing the supply to be interrupted by the "Palestinian Water Authority". An interruption in the supply "may cause inverse pumping of wastewater or other contaminants from the surrounding system" owing to a "breakage in the distribution system", and without adequate disinfection, interruptions "could lead to suitable conditions for biofilm bacterial regrowth, thus increasing the possibility of water contamination" (Yassin et al., 2006:1184). According to Yassin et al (2006), there were reports of biofilm developing in the water distribution systems and the most self-reported disease by "interviewees in Gaza City" was diarrhoeal diseases, being more prevalent among those that used the municipal water supply rather than those that utilized point-of-use water treatments (desalination and home filtration). "Intermittent water supply and sewage flood seem to contribute largely to self-reported diseases" (Yassin et al., 2006:1186).

Similar findings were noted in a study conducted by Lechtenfeld (2012), in the urban areas of Yemen. The "spatial analysis of coliform pollution in water pipes" showed that these polluted water pipes were providing polluted or impure water to many households, and that the "pipe pollution" can be attributed to water interruptions that take place for long periods of time (Lechtenfeld, 2012). Similarly, in a study conducted in Egypt by Roushdy & Sieverding (2016), it was found that access to an uninterrupted, improved water supply that is not stored before consumption "reduced the prevalence of diarrhoea in children under age 5 years in Egypt" (Roushdy & Sieverding, 2016:10). Therefore, it is important to recognise that the safe storage and handling of water at a household level together with the continuous uninterrupted supply of piped water prevent diarrhoea.

The StatsSA Community Survey 2016 report on state of basic delivery of services (2017), highlights that piped water as the main source of drinking water is used by approximately nine-tenths (89,9%) of South African households (Statistics South Africa, 2017). However, water retrieved from unsafe sources such as streams, wells, rivers or springs is still relied upon by 4,3% of South African households. In addition to this, though a large percentage of South African households rely on piped water, the delivery of this water is not always consistent. The survey noted that almost one in four (23.4%) of households in South Africa experienced some water interruptions in the three months before the study. When confronted with water interruptions, many households did not have alternatives, and those that did, used boreholes, rainwater and water tankers (Statistics South Africa, 2017).

"The water quality infrastructure index describes the engineering infrastructure in terms of the level of service that households have access to" (Statistics South Africa, 2017:29).

This level of service according to the water quality infrastructure varies greatly among provinces. The Western Cape was proven to have the highest level of water service quality whereas Limpopo was proven to have the lowest water service quality (Statistics South Africa, 2017). Moreover, rural areas located within Limpopo are faced with water supply interruptions or intermittent water supply (Kapwata, Mathee, Le Roux & Wright, 2018). In a study conducted by Kapwata et al. (2018:8), it was found that "Frequent interruptions in water supply also affects the quality of piped water due to the intrusion of contaminants into the distribution network during times of low pressure or when the water supply is turned off" (Kapwata et al., 2018:8). A frequent occurrence in many parts of South Africa is the "illegal connections to water pipes", this contributes to the interruption of water supplies. Water quality is directly affected when the water supply is shut off due to a regrowth of biofilm within the pipes (Kapwate et al., 2018). Leaks found in old and inadequate maintained infrastructure results in piped water being contaminated (Kapwata et al., 2018). Accordioning to Kapwata et al., (2018:8) “These findings were substantiated with microbial results showing that a large number of water samples from stand-pipes linked to the water reticulation system had detectable levels of either total coliforms, E. coli or both” (Kapwata et al., 2018:8).

Given the number of people that do not have access to piped water, and those that do have access but experience severe interruptions, alternative sources of water are sought out. However, many of these sources provide users with water unfit for immediate consumption as it is usually contaminated. Treating water before consumption can be recognised as a primary prevention method of diarrhoea (Geremew et al., 2018). Point-of-use water treatments have proven to be the most promising alternative to improving the quality of water by treating and maintaining the microbial quality of water (Zen et al., 2013).

2.4) Household Water Treatments

There are various types of Household/ Point-Of-Use water treatments that can be used that are particularly effective in areas that are faced with resource limitations, such as low-income countries or areas (Clasen et al., 2015).

There are four main categories of household water treatments, namely; Thermal (boiling) and Solar disinfection, Chemical disinfection, Filtration, Combined Flocculation and disinfection (Clasen et al., 2015; Zin et al., 2013). In a study conducted by Jones, Majowicz, Edge, Thomas, MacDougall, Fyfe, Atashband & Kovacs (2007), on water consumption patterns and gastrointestinal illness in British Columbia, it was found that from a total of 4610 respondents, almost half (around 47%) had reported using household water treatments for their tap water, common treatment methods included “jug filters (53%), followed by boiling (15.5%) and tap filters (14%). Approximately 3% of households (136/4610) used two water treatment methods” (Jones et al., 2007:61). According to Geremew et al. (2018), in Ethiopia, point-of-use water treatment methods that are being practiced, and which have proven to reduce the incidence of diarrhoea if used efficiently and consistently, include filtration, adding bleach (chemical disinfection), solar disinfection and boiling the water (Geremew et al., 2018).

Contrastingly, in a study conducted on water quality and use in rural communities in Limpopo, South Africa, by Edokpayi, Rogawski, Kahler, Hill, Reynolds, Nyathi, Smith Odiyo, Samie, Bessong & Dillingham (2018), It was found that residents do not usually treat their water at a household level because they trust and believe that they receive and have “high-quality water” (Edokpayi et al., 2018:12). On the odd occasion that they do treat their water, “it is by letting the water stand and settle or by boiling" (Edokpayi et al., 2018:12). Boiling, may be an effective water treatment method at a household level as it renders the water microbiologically safe (Rosa & Clasen, 2010; Rosa, Kelly & Clasen, 2016). However, letting the water "stand and settle" is much less effective. Rosa & Clasen (2010:296), in a study of HHWT in low and medium income countries state that "letting water strain through a cloth or letting it stand and settle, are treatment methods that are unlikely to render water microbiologically safe under most circumstances, suggesting that many households are committing time and effort to treat their water this way, even though these methods are not effective in improving the microbiological quality of water" (Rosa & Clasen, 2010:296). It should be noted that letting water stand and settle is a "pre-treatment step" to removing large suspended particles found in the water (Schutte, Morrison, Haarhoff, Geldenhuys, Loewenthal & Goosen, 2006).

2.4.1) Thermal (boiling) and Solar Disinfection

Boiling or heating water using fuel has proven to kill all microbial pathogens, making it quite effective in purifying water. This process can be carried out regardless of the dissolved components or murkiness of the water. Most pathogens are destroyed or deactivated once the water has been boiled or heated for a few minutes, regardless of whether the water has reached a rolling boil or not. In a study conducted by Brown & Sobsey (2012) on boiling as HHWT in Cambodia, it was found that boiling was the most widely used form of HHWT in both rurual and urban households, and "boiling resulted in significant reductions of E. coli in household stored water" (Brown & Sobsey, 2012:395). According to UNICEF (2008:4), "even heating to pasteurization temperatures (60º C) for a few minutes will kill or deactivate most pathogens" (UNICEF, 2008:4). Similarly, solar disinfection involves thermal and Ultra-Violet radiation, which work together to destroy microbial pathogens, this in turn reduces morbidity caused by diarrhoea as well as epidemic cholera.

According to Zin et al., (2013:9) "Treatment of water with solar radiation was practiced in ancient India more than 2000 years ago, which controls waterborne microbial contaminants by exposure to sunlight" (Zin et al., 2013:9). Solar disinfection was introduced in the 1980s (CDC, 2012) as a cost effective and efficient way to purify water, making it safe enough for consumption. The Swiss Federal Institute for Environmental Science had developed and promoted the "SODIS" (Solar Disinfection) system (UNICEF 2008; CDC, 2012). This system requires user's to fill clear plastic bottles, with water that is almost clear or has a "low turbidity", then oxygenate it by shaking the bottle that contains the water and then place the bottles outside, where it is exposed to direct sunlight, usually on rooftops, for between six to forty-eight hours, depending on how cloudy or sunny it is (UNICEF, 2008; CDC, 2012). According to CDC (2012) “The combined effects of UV-induced DNA alteration, thermal inactivation, and photo-oxidative destruction inactivate disease-causing organisms” (CDC, 2012:1). The protozoa, viruses and bacteria which causes diarrhoe are inactivated by SODIS.

According to CDC (2012) “In four randomized, controlled trials, SODIS has resulted in reductions in diarrheal disease incidence ranging from 9- 86%” (CDC, 2012:1). There has been a reduced presence of bacteria found in the water of developing countries as a result of SODIS. According to CDC (2012), “Over 2 million people in 28 developing countries use SODIS for daily drinking water treatment” (CDC, 2012:2). In terms of the cost of implementing solar disinfection water treatments, UNICEF (2008), estimates that it costs approximately “US$0.63” per person, per year (UNICEF, 2008:2). This proves that not only is it an effective household water treatment method, but it is also an affordable one. However, given the many advantages of solar radiation, it does not exist without disadvantages; due to the use of bottles, a limited amount of water can be disinfected at a time depending on the size and availability of the bottles; due to only being able to use water of low turbidity, water with high turbidity would have to be pre-treated and the time required to treat the water is lengthy (CDC, 2012). In addition to this, “thermal and solar disinfection do not provide residual protection against recontamination” (UNICEF, 2008). Therefore, many bottles are required by householders so they can let the water cool down and keep the treated water in the bottles until consumption.

2.4.2) Chemical Disinfection

In addition to boiling, chlorination is broadly used for treating water in the home as well as at a community level. There are various sources of chlorine, such as chlorine tablets known as hypochlorite (available and affordable); Sodium hypochlorite, which can be generated electronically from a salt and water solution or it can be household bleach; and chlorinated lime (UNICEF, 2008). In the 1990s, due to the cholera epidemic faced by South America, the Centers for Disease Control and Prevention (CDC) and the Pan American Health Organization (PAHO), had developed the Safe Water System (SWS) (CDC, 2012). “The treatment method for the SWS is point-of-use chlorination by consumers with a locally-manufactured dilute sodium hypochlorite (chlorine bleach) solution” (CDC, 2012:1). The chlorination method is utilised by adding the sodium hypochlorite solution (one full bottle cap for clear water or two full bottle caps for turbid water), in a container (standard size), stirring the solution in the water and waiting approximately thirty minutes before consuming. "Chlorine must be added in sufficient quantities to destroy all pathogens but not so much that taste is adversely affected" (UNICEF, 2008:3).

Hypochlorite solutions in amounts used for household water treatment destroys or inactivates bacteria and viruses found in the water that causes diarrhoeal disease, with the exception of certain protozoa such as Cryptosporidium (CDC, 2012). According to UNICEF (2008:3), "free chlorine inactivates more than 99.99% of enteric pathogens, the notable exceptions being Cryptosporidium and Mycobacterium species" (UNICEF, 2008:3). The Safe Water System implemented in various developing countries has proved to completely remove bacterial pathogens (CDC, 2012). According to CDC (2012:2) "In seven randomized, controlled trials, the SWS has resulted in reductions in diarrheal disease incidence in users ranging from 22-84%" (CDC, 2012:2). The Safe Water System has been implemented in approximately thirty-five countries including countries like Kenya and Uganda. With regard to the cost and affordability of Chlorination methods of household water treatment, UNICEF (2008), estimates that it would cost approximately "US$0.66" per person, per year (UNICEF, 2008:2). This proves to be an inexpensive, reliable method of treating water at a household level. However, the disadvantages of chlorination include; the disinfective efficacy in murky or turbid water remains to be low; potential objections to the taste and scent; chlorination by-products (bromoforms, chloroform, dibromochloromethane and dichlorobromomethane) may have potential long-term effects on health; protection from protozoa is relatively low and the solution's quality control must be ensured (Gopal, Tripathy, Bersillon & Dubey, 2007; CDC, 2012).

2.4.3) Filtration

Household filters promote routine use for a variety of reasons, they operate under any pH, temperature and turbidity conditions, they improve the appearance of the water, they are simple to use, no chemicals are introduced into the water with filters, thereby not affecting the taste or smell of the water (UNICEF, 2008; Zin et al., 2013). There are two main types of filters for use at a household level, ceramic and Bio-sand filters. Local ceramic facilities are where ceramic filters are produced, colloidal silver is then put into the filter to ensure that bacteria are completely removed in the treated water and to prevent future bacterial growth within the filter (CDC, 2012). There are various types of ceramic filters, however, the most common and widely implemented one is known as the "Potters for Peace" (PFP) design. It is shaped as a flowerpot, its water holding capacity is around eight to ten litres and it is positioned inside as ceramic or plastic container known as the storage container (CDC, 2012). The utilisation of the ceramic filters requires households to fill water into the top container or the ceramic filter itself, the water then flows through the ceramic filter or filters into a storage container, the water storage container has a tap or "spigot" embedded within it and the treated water is accessed via this tap.

The quality of production of the ceramic filters is what determines just how effective the filters are at removing viruses, bacteria and protozoa. According to UNICEF (2008:3) "Higher quality ceramic filters treated with bacteriostatic silver have been shown effective in the lab at reducing waterborne protozoa by more than 99.9% and bacteria by more than 99.9999%" (UNICEF, 2008:3). Ceramic filters have proven to be more successful in removing large bacterial organisms and protozoa than small viral organisms (CDC, 2012). According to CDC (2012), "Studies have shown adequate removal of bacterial pathogens in water filtered through high quality locally-produced and imported ceramic filters in developing countries. A 60-70% reduction in diarrheal disease incidence has been documented in users of these filters" (CDC, 2012:1). With regard to cost and affordability, UNICEF (2008), estimates that ceramic filters cost around "US$3.03" per person, per year (UNICEF, 2008:2). Ceramic filtration programs have been carried out in approximately twenty countries (CDC, 2012). However, like any other household water treatment, ceramic filters do not exist without disadvantages; recontamination can occur as a result of non-existent residual protection; effectiveness against viruses is low; maintenance is high as filters are susceptible to breakage (spare parts required) and needs to be cleaned on a regular basis; a lengthy flow rate for non-turbid water of around one to three litres per hour (CDC, 2012).

In addition to ceramic filters, exist Bio-sand filters made for household water treatment. Bio-sand filters are concrete or plastic containers of a specific width and length that contains layers of sand and gravel, a small amount of water is added, just enough to allow for the growth of a bioactive or "slime" layer above the sand, this slime layer is used to remove suspended microbes and solids, reducing "disease-causing organisms" found in the water (UNICEF, 2008; CDC, 2012). The Bio-sand filter is a modification of the slow-sand filter which utilises the same structural design, materials and sand filter process of the Bio-sand filter, just at a larger scale (municipal water treatment level) (CAWST, 2012; UNICEF, 2008). Slow-sand filters permit the continuous use of the filter which requires a continuous flow of water, whereas the Bio-sand filter permits the intermittent use of the filter which requires water to stop flowing.

The Bioactive layer in the slow-sand filter is oxygenated by the continuous flow of water, and the bioactive layer in a Bio-sand filter is oxygenated by how little water is filled in the filter, which allows the bioactive layer to breathe and remain alive (CAWST, 2012; UNICEF, 2008). The utilisation of a Bio-sand filter is straightforward, household users would need to fill water at the top at the filter, (the water will flow through the different layers of the filter) and collect the water the treated water from an "outlet pipe" located at the bottom of the filter (CDC, 2012). The main disadvantages of sand filters are similar to ceramic filters; the effectiveness against viruses are low; recontamination can occur as a result of non-existent residual protection; the bioactive layer can be destroyed and its effectiveness can be reduced by routine cleaning; due to the weight of the filter, initial cost is high and transportation is laborious (CDC, 2012).

2.4.4) Combined Flocculation and Disinfection

Highly turbid or murky water is one of the main problems all other household water treatment methods are faced with. According to UNICEF (2008:4) "Solids can use up free chlorine and other chemical disinfectants, cause premature clogging of filters, and block UV radiation essential in solar disinfection" (UNICEF, 2008:4). Flocculation has proved to be a cost-effective method to manage turbid water and has also proved to reduce protozoa and other microbial pathogens found in water, in addition to this, a disinfectant is still required in order to ensure "complete microbial protection" (UNICEF, 2008:4). As a result, combined flocculation and disinfection sachets were manufactured. These sachets are sold for household use (UNICEF, 2008). In order to utilise combined flocculation and disinfection sachets, household users are required to simply collect water in a bucket (approximately ten litres), pour the contents within the sachets into the water, mix the contents into the water by stirring the water for approximately five minutes, the water then has to be strained into another (cleaned) container or bucket by using a cotton cloth, household users are then required to leave the water for approximately twenty minutes to allow for the inactivation of any micro-organisms by the disinfectant (CDC, 2012).

An example of the sachets would be P&G™ Purifier of Water™, which was developed by The Procter & Gamble Company and the Centers for Disease Control and Prevention (CDC, 2012). This sachet contains the flocculant ferric sulfate and the disinfectant calcium hypochlorite (CDC, 2012). According to CDC (2012:1) "sachets are now centrally produced in Pakistan and sold to nongovernmental organizations (NGOs) worldwide at a cost of 3.5 US cents per sachet" (CDC, 2012:1). The sachets of combined flocculant and disinfectants, when used even in water with a high turbidity, removes a great number of protozoa, bacteria and viruses. It has also proved to remove non-microbial contaminants such as arsenic, making it distinctively different from the other household water treatments (UNICEF, 2008). According to CDC (2012), “P&G™ has been documented to reduce diarrheal disease from 90% to less than 16% incidence in five randomized, controlled health intervention studies” (CDC, 2012:1). UNICEF (2008:4) states that combined flocculation and disinfection sachets “has been shown to reduce waterborne cysts by more than 99.9%, viruses by more than 99.99% and bacteria by more than 99.99999%” (UNICEF, 2008:4). With regard to the cost and affordability of combined flocculation and disinfection, UNICEF (2008), estimated that combined flocculation and disinfection costs around “US$4.95” per person, per year (UNICEF, 2008:2). Making it the most expensive household water treatment in comparison to the three aforementioned household water treatments. However, the combined flocculation and disinfection method does not exist without disadvantages; users may have to be shown how the product works due to the different steps, this requires training; a fair amount of equipment is required, such as the cotton cloth, not one but two different buckets as well as a stirrer; relative cost increases as the litres of water increases, for example, one P&G™ sachet treats only ten litres of water (CDC, 2012).

2.5) Environmental and Personal Illness Control Factors Associated with Diarrhoea and Child Mortality

Mosley & Chen’s analytical framework of child survival identifies environmental factors and personal illness control to be proximate/ intermediate determinants of child survival. For the purpose of this research, environmental factors consist of sources of water and toilet facilities, and personal illness control factors includes handwashing and safe disposal of stools.

2.5.1) Environmental Factors

Various studies have revealed that environmental factors are significantly associated with or contribute to childhood diarrhoea. The main factors being sources of water and toilet facilities. In a study conducted in a town called Jigjiga, located in Eastern Ethiopia, Bizuneh, Getnet, Meressa, Tegene, & Worku (2017:4), revealed that “children living in households where [piped] water was not available were found to be at higher risk of having diarrhea” (Bizuneh et al., 2017:4). It was found that communal stand pipes were the main source of water for most people, they receive their water in plastic barrels that are delivered to their houses by donkey carts (Bizuneh et al., 2017). The town is intermittently supplied with water, this forces the people to find alternative sources of water, these alternative sources are usually unprotected and unsafe. This reveals that diarrhoeal illness can be reduced more through a greater supply (quantity) and increased accessibility of water and water sources respectively, making these factors more important than the quality of water received (Bizuneh et al., 2017). “This lack of accessible and consistent water supply could serve as a disabling factor for mothers’ safe hygiene practices which could explain the higher prevalence of diarrhea in households without water” (Bizuneh et al., 2017:4).

In a study conducted by Imada, Araújo, Muniz & Pádua (2016) on the “Socioeconomic, hygienic, and sanitation factors in reducing diarrhea in the Amazon” (Imada et al., 2016:1), it was found that the river was predominantly where people got their water from, there were very few houses that presented “connections of the public water supply” in their homes. Greater than one third of the houses did not have piped water, affecting the health of children, “there was a higher probability of diarrhoea in children who did not use water from the public network” (Imada et al., 2016:4). Contrastingly, in a study conducted by Lechtenfeld (2012), it was found that those that received piped water, had been receiving polluted water from polluted pipes as a result of water interruptions, additionally, the way in which people handled the water also contributed towards the contamination of the drinking water. According to Lechtenfeld (2012:2), “substantial water pollution occurs within households, improved water handling and storage, such as the use of closed water containers that prevent hand-to-water transmission of pathogens can help to reduce such ‘intra-household pollution” (Lechtenfeld, 2012:2)

Studies have revealed the importance of adequate toilet facilities in reducing diarrhoea. In a study of childhood diarrhoea conducted in North West Ethiopia, Mihrete, Alemie, & Teferra, (2014), revealed that children from households with proper, toilet facilities were six-times less likely to have diarrhoea than children from households that did not have proper toilet facilities. In addition to this, Bado et al. (2016), in a study of childhood diarrhoea in sub-Saharan countries, revealed that children from households that use proper, improved toilets are less likely to have diarrhoea than the children that come from households that use latrines. Consistently, Mohammed & Zungu (2016), in a study conducted in Ethiopia, found that “households with improved toilet facilities had a lower prevalence of diarrhoeal disease than those children whose households used unimproved toilets” (Mohammed & Zungu, 2016:127). According to Imada et al. (2016), “sanitation conditions improved with the increase of bathrooms with toilets” (Imada et al., 2016:1).

2.5.2) Personal Illness Control

According to Bizuneh et al. (2017:4), in Ethiopia, childhood diarrhoea can be attributed to "improper child stool disposal, improper refuse disposal, poor handling of water in households and lack of hand washing facilities" (Bizuneh et al., 2017:4). Additionally, Mihrete et al. (2014), in a study conducted in 'Benishangul Gumuz Regional State, North West Ethiopia', found that the children from households that had safely disposed of children's stools were sixty percent less likely to have diarrhoea than the children from households that had disposed the stool of children in an unsafe way. Various studies prove that there is a negative relationship between safe stool disposal and childhood diarrhoea, in other words, an increase in safe stool disposal results in a decrease in diarrhoea in children (Curtis, Cairncross, & Yonli, 2000). In a study conducted by Sahiledengle (2019), on the "Prevalence and associated factors of safe and improved infant and young children stool disposal in Ethiopia", it was found that the unsafe disposal of "excreta" is highly associated with the "burden of diarrhoea" (Sahiledengle, 2019:6). Curtis et al. (2000), states that safe stool disposal is the "primary barrier to transmission" of diarrhoea (Curtis et al., 2000:22).

In addition to safe stool disposal, handwashing plays an important role in reducing the transmission of diarrhoea. Bizuneh et al. (2017), in a study, stated that the "lack of handwashing stand was a significant factor to predict diarrhea among under five children" (Bizuneh et al., 2017:5). Feleke et al. (2018), in a study conducted in Northwest Ethiopia, stated that there is a notable relationship that exists between sharing sanitation facilities (specifically in slums) and the incidence of diarrhoea. It was also found that handwashing using soap is most efficient in reducing the occurrence and transmission of diarrhoea when it is done at critical times, for example; prior to food preparation and "after defecation". In a study, Mohammed & Zungu, (2016), found that when households had a designated place for handwashing, children "were 4.0 times less likely to have diarrhoea" than where no place had been designated (Mohammed & Zungu, 2016:127). To reduce diarrhoeal transmission and for the overall hygiene of a household to improve, "the primary caretaker must have easy access to a place to wash his or her hands, which has water and soap within easy reach" (Mohammed & Zungu, 2016:128).

According to Curtis et al. (2000:26), "it is important to distinguish between hand-washing as a primary barrier (to remove faecal matter after contact with stools) and handwashing as a secondary barrier (before preparing food, handling fluids, feeding, eating)", this is attributed to the fact that handwashing requires water which is not always available in abundance to people, especially those in developing regions, residing in rural, low-income and slum areas; as well as soap, which can prove to be expensive to many people and therefore not always available or accessible. Handwashing becomes a restricted activity for these reasons (Curtis et al., 2000).

2.6) Socio-Economic Factors Associated with Household Water Treatment, Diarrhoea and Child Mortality

Mosley & Chen's Analytical framework of child survival highlights various socio-economic determinants that must operate through or function via the proximate determinants (maternal age, parity, marital status and place of residence), in order to affect the survival of a child (Mosley & Chen, 1984). For the purpose of this research, three main socio-economic determinants of diarrhoea, and household water treatment have been identified; Mother's education; Mother's occupation and; Household income and wealth. According to Kumi-Kyereme & Amo-Adjei (2015:132), "Diarrhoea is considered a symptom of wider socioeconomic inequality within and between populations" (Kumi-Kyereme & Amo-Adjei, 2015:132), in addition to this, Bizuneh et al., (2017:2) state that "Many of the risk factors for contracting diarrheal illnesses are associated with poor socioeconomic conditions" (Bizuneh et al., 2017:2).

2.6.1) Mother's Education

In a study conducted by Geremew et al. (2018), on 'household water treatments in Ethiopia', it was found that household water treatments were used more frequently (prior to consumption) in households where the household head, had obtained (at least) primary level education and less frequently in households where the household head did not have any formal education. According to Geremew et al. (2018:4) "Household head with higher education had the odds of 7.42 times higher in 2005, 6.65 times higher in 2011, and 3.27 times higher in the reported use of appropriate water treatment methods compared to house head who had no education" (Geremew et al., 2018:4). Daniela, Dienerc, Pandea, Jansenb, Marksc, Meierhoferc, Bhattad, & Rietvelda. (2019), in a study on household water treatment in Nepal, it was found that households headed by, and consisting of educated individuals, with children under the age of five years and had "piped water connections" were more likely to adopt household water treatments than households with uneducated individuals. Education was observed to have an "overall positive effect on household water treatment adoption" (Daniela et al., 2019: 852). Consistently, in a study conducted by Geremew & Damtew. (2019), on HHWT in sub-Saharan African countries, it was revealed that the adoption of HHWT was higher among households with an "educated household head" (Geremew & Damtew, 2019:6). Mother's education indirectly affects the survival of a child, causing it to have a direct association with diarrhoeal morbidity and mortality (Bado, Susuman & Nebie, 2016).

Various studies conducted in developing countries reveal that children, under the age of five years, from uneducated mothers, are more likely to suffer from diarrhoeal related diseases and deaths than children from educated mothers (Bado et al., 2016). In a multilevel study concerning the 'Country characteristics and acute diarrhea in children from developing nations', Pinzón-Rondón, Zárate-Ardila, Hoyos-Martínez, Ruiz-Sternberg, & Vélez-van-Meerbeke (2015:8) state that "in comparison to children of highly educated mothers the children of mothers without formal education, with elementary education and with high school education had 42, 45 and 29 % higher odds of having diarrhea, respectively" (Pinzón-Rondón et al., 2015:8). The level of autonomy and potential to empower oneself, in order to provide the necessary care for one's child, is revealed by a woman's (mother's) level of education (Bado et al., 2016).

Feleke et al. (2018), found that households which experienced diarrhoea among children that were under the age of five, were households that had mothers/caregivers that were illiterate. It was stated that in order to decrease diarrhoea, experienced by children aged five years and below, there needs to be an increase in the education of mothers/caregivers (Feleke et al., 2018). Mwambete, & Joseph. (2010), in a study conducted in Tanzania, state that a mother's poor or inadequate knowledge on the "predisposing factors" of diarrhoea among children, had a direct correlation with the mother's level of education. Additionally, in a study conducted in Nepal by Budhathoki, Bhattachan, Yadav, Upadhyaya, & Pokharel (2016), it was found that children with educated mothers (secondary and higher), were less likely to suffer from diarrhoeal diseases than children with uneducated mothers or mothers that had "lesser education" (Budhathoki et al., 2016:5). This can be attributed to the fact that more educated mothers may be more knowledgeable on diarrhoeal prevention methods and the overall "health status of her child" (Budhathoki et al., 2016:5).

Bizuneh et al. (2017:3), in a study, revealed that "Children of educated mothers were protected against diarrhea as compared to children of mothers with no formal education", this was attributed to the fact that educated mothers are more likely to be aware of the importance of household water treatments, hygiene, handling water in a clean and safe manner, safely and properly disposing waste and "good child feeding practices" (Bizuneh et al., 2017:4). Similarly, in a study conducted in Ghana, by Kumi-Kyereme & Amo-Adje (2014:138), it was stated that "mothers who are educated are more likely to have better skills in childcare practices, such as regular hand washing with soap prior to feeding children" (Kumi-Kyereme & Amo-Adje, 2014:138).

Mothers that are educated have a better chance at reducing child mortality and ensuring child survival than mothers that are uneducated. There are five principal pathways that connect child health and maternal education; "socio-economic status that has been improved, knowledge on health, contemporary attitudes toward health care, the autonomy of women, and fertility/reproductive behaviour" (Ashagidigbi, Adewumi, Olagunju & Ogunniyi, 2018; Maniruzzaman, Suri, Kumar, Abedin, Rahman, El-Baz, Bhoot, Teji, & Suri, 2018).

2.6.2) Mothers Occupation

In a study conducted in Northwest Ethiopia on HHWT practice, by Birara, Destaw, & Addis (2018), it was found that, the occupational status of respondents was a "significant predictor of household water treatment practice" (Birara et al., 2018:36). Daily workers proved to be "2.6 times more likely" to treat their water prior to consumption than merchant workers (Birara et al., 2018:34). In the study it is not clear what exactly is meant by a daily worker or a merchant worker, therefore the general definition of each occupation can be assumed, a daily worker or labourer is usually unskilled and gets paid by the day, for example domestic workers (Jewell, 2006). A merchant is someone that engages in trade, buying and selling goods, this could be on a large scale (wholesale level) or at a small-scale (informal vending or selling practices) (Jewell, 2006).

Along with mother's education, another socio-economic determinant of childhood diarrhoea would be mother's occupational status (Mihrete et al., 2014). According to Mihrete et al. (2014:7), "A study in Egypt showed that children whose mothers were not working, or farmers or manual laborers had a significantly higher frequency of diarrhea" (Mihrete et al., 2014:7). Additionally, according to Thiam, Diène, Fuhrimann, Winkler, Sy, Ndione, Schindler, Vounatsou, Utzinger, Faye, & Cissé (2017), in a cross-sectional study of the 'Prevalence of diarrhoea and risk factors among children under five years old in Mbour, Senegal', it was found that diarrhoeal risk was related to mother's occupation. Children of mothers who worked in the public or private sector had a lower diarrhoea risk in comparison to the children of mother's that stayed at home (housewives) (Thiam et al., 2017).

Contrarily, a study conducted in "Benishangul Gumuz Regional State, North West Ethiopia", revealed that "children of mothers who had work were about two times more likely to have diarrhea compared to children of mothers who were not working" (Mihrete et al., 2014). Consistent with another study in Ethiopia, conducted by Takele, Zewotir, & Ndanguza. (2019), revealing that children of currently working mothers, rather than mothers who are not currently working, have a higher risk of suffering from "diarrhoea morbidity" (Takele et al., 2019:6). In addition to this, According to Pinzón-Rondón et al. (2015), in a multilevel study concerning childhood diarrhoea in developing nations, it was found that "children of working mothers had 14 % higher odds to have diarrhea than those of mothers who did not work" (Pinzón-Rondón et al, 2015:8).

This is attributed to time lost with children when mothers are at work, "the mothers' absence from the household, along with poor social support has negative effects on child health" (Pinzón-Rondón et al, 2015:8). Studies also reveal that the association between mother's occupation and childhood diarrhoea differs according to the type of occupation acquired. "In Nigeria, mothers in informal occupations had 23% more likelihood of child diarrhea compared to mothers in other occupational categories" (Mihrete et al., 2014:7). According to Bado et al. (2016), children had a lower risk of diarrhoeal morbidity when their mothers did not engage in any primary occupations and, children had a higher risk of diarrhoeal morbidity when their mothers engaged in agriculture or trade as their main activity. Mother's/ caregiver's occupational status as well as the partner's occupational status plays a vital role in the decision making of diarrhoeal treatment.

According to Aremu, Lawoko, Moradi & Dalal, (2011), in a study concerning treatment options of childhood diarrhoea in sub-Saharan Africa, it was found that Mothers/ caregivers "who were manual workers and those that are professionals relative to those that were not working, were more likely to selecting medical centre and pharmacies to treat diarrhoea compared with no treatment" (Aremu et al., 2011:3). Medical centres and home-care treatments for childhood diarrhoea were options more frequently chosen by mothers/caregivers who engaged in manual work, or were considered "manual workers", as opposed to "professional working-class" mothers/caregivers who relied more on support from pharmacies and "medical vendors" to treat diarrhoea (Aremu et al., 2011).

2.6.3) Household Income and wealth

In the study 'Drinking water consumption patterns in British Columbia: An investigation of associations with demographic factors and acute gastrointestinal illness', Jones, Majowicz, Edge, Thomas, MacDougall, Fyfe, Atashband & Kovacs (2007:62), state that "Household income was unconditionally associated with specific types of household water treatment methods" (Jones et al., 2007:62). In the study, the lowest income level was identified as "$20,000–$39,000", the middle income level was identified as "$40,000– $59,000", and the highest income levels were identified as "$60,000–$79,000 and $80,000", it was found that the lowest and middle income level households were more likely to use boiling as a water treatment method and the highest income level households were less likely to use boiling as a water treatment method. Instead, households of the highest income level utilized activated carbon water treatment methods. Boiling as a household water treatment method is less expensive than using activated carbon devices to treat water at a household level, therefore boiling was utilized more frequently by low and middle-income households than high income households. This study indicated that household income is significantly associated with household water treatment. It directly influences the choice of household water treatment utilized by the household (Jones et al., 2007).

Geremew et al (2018), highlights that households in the highest/higher wealth quintiles in comparison to the households in the lowest wealth quintiles, are more likely to treat water using suitable household water treatment methods. In a study conducted in Ethiopia, "The odds of reported use of appropriate treatment methods among households found in the highest wealth quintile in 2005, 2011, and 2016 were 2.77, 5.02, and 1.83 times higher, respectively, than households found in poorest wealth quintile" (Geremew et al., 2018:4). This finding on the relationship between HHWT and household wealth concurred with the findings Blum, Null & Hoffmann (2014) in rural Kenya on 'marketing HHWT (WaterGuard) and the willingness to pay'. They found that all participants of the study that showed interest in the product but did not purchase it at the time, were unable to afford it as a result of "not having money in the house" (Blum et al., 2014:1879). "We find that wealthier households are significantly more likely than poorer households to purchase WaterGuard at the market price" (Blum et al., 2014:1881). Households that fall within the higher wealth quintiles or are "relatively wealthy" are more likely to treat their water at a household level prior to consumption (Daniela et al., 2019; Geremew & Damtew, 2019).

In the study ‘Diarrhoea morbidity in children in the Asaro Valley, Eastern Highlands Province, Papua New Guinea’, Wyrsch, Coakley, Alexander, Saleu, Taime, Kakazo, Howard, & Lehmann (1998), revealed that the incidence rate of diarrhoea in children under-five years was greater in low and medium cost housing areas as opposed to high cost housing areas. In addition, “this difference was greatest in children aged 6-11 months; in this age group incidence in medium and low-cost areas was 4.1/child-year compared to 2.3/child-year in the high cost area” (Wyrsch et al., 1998:10). The difference in diarrhoeal incidence rates between children from rich and poor households can potentially be attributed to the fact that rich households can afford and have better access to clean water, household water treatment methods, clean and safe environment, nutritious foods and health services (Lartey, Khanam, & Takahashi, 2016).

2.7) Demographic Factors Associated with Household Water Treatment, Diarrhoea and Child Mortality

Using Mosely & Chen’s analytical framework for child survival, there are specific demographic factors that can be regarded as proximate determinants. Proximate determinants are factors or determinants that directly affect or influence the morbidity and mortality of a child. For the purpose of this research three main demographic factors of household water treatment, diarrhoea and child mortality have been identified; Maternal age; marital status and; place of residence (rural/urban). These factors are said to directly influence the morbidity and mortality of children under-five years (Mosley & Chen, 1984).

2.7.1) Maternal Age

According to Ogada (2012:19) “the probability of dying in early childhood is much greater if children are born to mothers who are too young or too old” (Ogada, 2012:19). Ogada (2012:20) states that “a very young mother, being inexperienced may not be able to take proper care of the young infants” (Ogada, 2012:20). Woldeamanuel (2019), in a study of child mortality in Ethiopia, mortality was higher for children that were born from young mothers (age at first birth below seventeen), than children that were born from older mothers (age at first birth twenty-five and above). (Woldeamanuel, 2019). In addition to this, the study showed that children under the age of five, born from mothers over the age of forty were more vulnerable to death, than those born from mothers below the age of forty. It was stated that “the highest odds, for under-five deaths, were among mothers who gave birth lately after 45 years old” (Woldeamanuel, 2019:13).

According to Fall, Singh Sachdev, Osmond, Restrepo-Mendez, Victora, Martorell, Stein, Sinha, Tandon, Adair, Bas, Norris, Richter & the COHORTS investigators (2015:366), "advanced maternal age (≥35 years) is associated with increased stillbirths, preterm births and intrauterine growth restriction", this is a result of various factors including a low level of education, a low socioeconomic status as well as, an increased parity of the mother; in addition, educated mothers might delay pregnancies due to their careers (Fall et al., 2015). Research shows that older mothers are at a higher risk of "pregnancy complications" and the associated consequences this may have on the child (Fall et al., 2015).

Similarly, Pinzón-Rondón et al. (2015:8), revealed that "younger mothers reported diarrhea more frequently than older ones, which could be explained in part by the younger mothers' lack of experience with child care" (Pinzón-Rondón et al., 2015:8). Fall et al., (2015:366) state that "young maternal age at childbearing (≤19 years) is associated with an increased risk of preterm birth and intrauterine growth restriction, infant mortality, and child undernutrition" (Fall et al., 2015:366). This is a result of shortened breastfeeding periods, behavioural immaturity making the mother "less able to attend to their infant's needs", low socioeconomic status, low level of education, unstable relationships/partnerships and "if still growing, their nutritional needs compete with those of the fetus" (Fall et al., 2015:366). In addition, in the study, it was found that "children of young mothers and mothers of advanced age had an increased risk of low birthweight and preterm birth, stunting in infancy" (Fall et al., 2015:374).

2.7.2) Marital Status

Marital status directly affects the well-being of children for various reasons. According to Clark & Hamplová (2011), the family environment is reflected through marital status, it encompasses exactly how many adults are present and able to take care of the children on a daily basis as well as the "household resources available to them" (Clark & Hamplová, 2011:3). Often, children grow up in households with only one biological parent present, this is due largely to marital instability which potentially leads to divorce and separation; and non-marital childbearing, this is when children are born out of wedlock, which occur in two different ways. One, when young women who have never been married fall pregnant; two, divorced or widowed women at the time of birth, who were previously married. However, over time, there has been an increase in non-marital childbearing, there are many factors that have contributed to this; the emergence of cohabiting unions, where unmarried couples live together, this increases the risk of nonmarital births.

Cultural and social norms are evolving over time, according to Miller, Park & Thomas (2019:1) "increased acceptance of premarital sex, out-of-wedlock childbearing, abortions, divorce, decisions to never marry, and greater labor force participation by women are thought to contribute to upward trends in nonmarital childbearing" (Miller et al., 2019:1). However, non-marital childbearing is said to have consequences on the well-being of the child, Miller et al. (2019:6), state that "children of unmarried mothers are more likely to live in poverty", this would directly affect the environment the child grows up in and the quality of life the child would have as well as the child's access to necessities that ensures healthy growth and survival. Children growing up in one parent households is far more complex in South Africa due to low rates of marriage, the "effects of apartheid policies on family structure" (Posel & Rudwick, 2011:3), and the practice of *ilabolo* which is "the custom involving the provision of marriage payments in cattle or cash, from the groom's family to the parents of the bride" (Ndebele, 2013; Posel & Rudwick, 2011:1). According to Ndebele (2013), "the number of marriages registered every year is declining despite an increasing population" (Ndebele, 2013:1). In addition, research has shown that in recent times *ilabolo* delays or prevents marriage completely as the marriage cannot take place unless the *ilabolo* payment has been made in full, in order for this to happen the groom has to save for a very long time. As mentioned previously, a consequence of single-parent households is that it is more vulnerable to poverty (Ndebele, 2013; Miller et al, 2019).

A common occurrence in Eastern and Southern Africa as a result of premarital sex, are premarital births (Clark & Hamplová, 2011). "In one study of nine countries in eastern and southern Africa, premarital births ranged from 13% of first births in Malawi to 56% of first births in Namibia" (Clark & Hamplová, 2011:3). In many of the eastern and southern African countries, marriages end in divorce and in countries affected most by the AIDS epidemic, women are at risk of losing their husbands and becoming widows. Woldeamanuel (2019) in a study of under-five mortality in Ethiopia, found that there was a high correlation or association with marital status and under-five mortality, in an analysis, it was revealed that the percentage of child deaths were higher among unmarried mothers than married mothers (Woldeamanuel, 2019). In addition, the World Family Map (2014:5), revealed that "children raised by mothers who have experienced union instability are more likely to have health problems, especially diarrhea and to die, than children raised by a mother who has remained in her first union since before their birth" (World Family Map, 2014:5). Union instability includes losing a spouse (widow), the dissolution of a marriage (divorce) or a cohabiting relationship (separation), as well as a re-partnership (cohabitation). Diarrhoea was found to be less common among children born to mothers that remained in their first union and more common among children born to mothers that have re-partnered (16% and 35% more common in Africa and Asia respectively). Previously, the idea of living with someone before marriage was frowned upon in many cultures, religions and countries and for that reason, it rarely ever occurred. However, recently, cohabitation has become "an important precursor or alternative to marriage in many countries" (World Family Map, 2014:14).

Many young or divorced individuals are choosing to cohabit for various reasons, such as not being financially, emotionally or mentally ready for marriage as well as the mere fact of just not wanting to marry at all. De Wet & Gumbo (2016), in a study conducted in South Africa, it was found that cohabitation occurs predominantly among the youth (ages 15-35) and that the reason for this is because this "age group is developmental, experimental and transitional" (De wet & Gumbo, 2016:2661), in other words, with their lives just beginning (in the process of completing their studies, getting their first job, achieving social and financial independence etc), cohabitation is the most viable option (De Wet & Gumbo, 2016). However, very often, there is a child involved that may suffer from the cohabitating partnership as it would only include just one biological parent (most of the time). According to Golub & Reid (2015:9), many women become pregnant in their teenage years and only find a suitable "residential romantic partner" much later in their lives (twenties and thirties). This may result in the child being exposed to more than just one cohabiting partnership. Cohabiting partnerships are very often associated with poverty (Golub & Reid, 2015; Manning, 2015). According to World Family Map (2014) & Manning (2015), cohabiting partnerships have many consequences for children, including the inconsistent attention and care that the child requires regardless of the environmental conditions the child is exposed to (World Family Map, 2014; Manning, 2015). "For example, households with poor resources, such as those that lack piped water, may nonetheless have healthy children if caregivers take time to boil drinking water" (World Family Map, 2014:50).

2.7.3) Place of Residence (Rural/Urban)

According to Geremew et al. (2018), the use of point-of-use or household water treatment occurs at a higher rate in urban areas, than rural areas. It was found that, "the odds of using appropriate point-of-use water treatment methods in urban area are 1.51 times higher in 2005, 1.80 times higher in 2011, and 1.58 times higher in 2016 compared to rural area" (Geremew et al., 2018:4). According to Bado et al. (2016), in Niger, Mali and Nigeria, children that reside in rural areas and have uneducated mothers are at greater risk of diarrhoeal disease than children that reside in urban areas and have educated mothers. In Mali, "children living in rural areas were 1.3 (2001 DHS) and 1.5 (2006 DHS) more likely to have a diarrheal disease compared with children living in urban areas" (Bado et al., 2016:8). Wyrsch et al. (1998), revealed that the incidence of diarrhoea is significantly higher in rural areas than urban areas (Wyrsch et al., 1998). In a study conducted in a rural community in Kenya, that showed a high prevalence of diarrhoea among children under-five being highly attributable to "unclean water"; it was found that even though the rural "district has expansive water surfaces" most of the water is "raw and unclean", resulting in very little access to clean drinking water and an increased risk to diarrhoeal diseases (Othero et al., 2008:143).

Bogale, Gelaye, Degefie, & Gelaw (2017) revealed in a study on the 'spatial patterns of childhood diarrhea in Ethiopia', that the trends of childhood diarrhoea increased in remote and rural areas. This is consistent with the findings of Kumi-Kyereme & Amo-Adje (2014), that found the odds of a diarrhoeal infection to be higher for children residing in rural areas than children residing in urban areas. According to Bogale et al. (2017:6), "This is because of the fact that adequacy, availability and accessibility of safe water is not satisfactory in all regions of the country especially, in the remote and rural areas" (Bogale et al., 2017:6). Additionally, Siziya, Muula & Rudatsikira (2013), states that the difference between the incidence of diarrhoea in rural and urban areas can be a result of the difference in wealth between rural and urban areas (with the urban being wealthier than the rural), which subsequently affects the level of hygiene achieved, "especially in areas where there is a cyclic drought that may be affecting more the vulnerable rural population" (Siziya et al., 2013:381). Where children reside determines how they live, their quality of life, how they go about their daily lives and whether they have access to necessary services and facilities that are required for survival (Woldu et al., 2016).

In various studies conducted in numerous developing countries, there had seemed to be a trend across most regions where child death occurs at a higher rate in rural areas than urban areas. According to Ashagidigbi et al. (2018), in a study of child mortality in rural Nigeria, "The trend of infant and child mortality in Nigeria is such that the greater percentage of child deaths occurs in the rural area" (Ashagidigbi et al., 2008:208). In 2008, child mortality was higher in the rural areas of Nigeria than the urban areas of Nigeria with the rural areas experiencing 191 child deaths per 1000 live births and, the urban areas experiencing 121 child deaths per 1000 live births (Ashagidigbi et al., 2018). The high child mortality rates experienced in rural areas can be attributed to a few factors; the high levels of illiteracy and poverty, an absence of necessary basic infrastructure; relevancy and influence of cultural and religious beliefs and; a "lack of medical personnel and equipment as well as the attitude and expertise of health personnel" (Ashagidigbi et al., 201:208).

Contrastingly, a study conducted by Lartey, Khanam & Takahashi (2016), shows how, at first, the rural areas of Ghana had experienced a higher under-five mortality rate than the urban areas. It then goes on to show how the under-five mortality rates are in fact reducing in rural areas and increasing in urban areas. They attribute this to the "effect of urbanization and the urban poor" (Lartey et al., 2016:4). It is said that urbanization, though it reduces absolute poverty, it does hardly anything for the urban poor. The decision of households that are poor, to reside in the informal urban areas, as a result of "poor income accessibility", mainly affects the children of the household. Consequently, "poor parents are not able to afford good nutrition and better healthcare for their children" (Lartey et al., 2016:4). In addition, according to Schrecongost, Wong, Anda, Gerritsen & Dutton (2015:26), it was found that in many informal urban and peri-urban settlements "residents may share piped water with neighbors if they are unable to secure household connections" and "residents appear to rely almost exclusively on shallow wells (near the home) and surface water (farther from the home)" (Schrecongost et al., 2015:26). Many informal urban areas are faced with a lack of clean piped water, and the consequences of this are felt most extensively by the children of the household.

2.8) Conclusion

This chapter reviewed literature relevant to the study in line with the study objectives. It began by looking at diarrhoea in children under five and water supply in the household, this section highlighted how diarrhoeal diseases affect the health of children under five as well as the state of water supplies at a household level. Water interruptions followed, highlighting the nature of water interruptions and its effect on health, HHWT/point-of-use water treatments were identified. The section on the environmental factors and personal illness control associated with diarrhoea and child mortality highlighted environmental factors such as sources of water and toilet facilities, as well as personal illness control practices, such as stool disposal and handwashing. A section on socioeconomic factors associated with HHWT, diarrhoea and child mortality highlighted the education and occupation of mothers as well as household income and wealth. Lastly, the section on demographic factors associated with HHWT, diarrhoea and child mortality highlighted maternal age, marital status and place of residence. The categorisation of literature in this chapter and of the variables to follow in the rest of the chapters was influenced by the theoretical framework.

CHAPTER THREE

METHODOLOGY

3.1) Introduction

The primary objective of this study is to determine and investigate the factors associated with household improvement of drinking water and diarrhoea among children (under-five), in South Africa. The following chapter will describe the methodology employed for the research. The chapter begins by describing the location of the study, South Africa; followed by a description of the primary source of data, SADHS 2016. Thereafter, the variables related to diarrhoea among children under five years and water treatment at a household level are highlighted, followed by a discussion of the data analysis methods. Lastly, Ethical consideration as well as validity, reliability and rigour of the study is discussed.

3.2) Location of the Study

(OnTheWorldMap, 2019)

Figure 3: Map of South Africa

Figure 3 shows the location of the study**,** South Africa. The country has a land surface area of 1 220 813 kilometres squared and is made up of nine provinces, namely; Northern Cape, Western Cape, Eastern Cape, Gauteng, Kwa-Zulu Natal, Mpumalanga, Limpopo, North West and the Free state. South Africa has eleven official languages and a diverse range of people that reside within the country. The South African population is estimated at 55.7 million. South Africa has a poverty rate of 21.5%, and a poverty headcount of 58.6% for females and 54.9% for males (Statistics South Africa, 2019). Urbanization of the country has increased over the years from 60.62% of the population residing in urban areas in 2007 to 65.85% of the population residing in urban areas in 2017 (Statista, 2019). Although a significant proportion of the population live in poverty, 89.1% have access to running water (UNDP, 2019).

3.3) Source of Data

This research will be a secondary data analysis of the 2016 SADHS (South Africa Demographic and Health Survey). In collaboration with the worldwide demographic and health survey program, the SADHS 2016 is the third Demographic Health Survey to be conducted in South Africa (NDoH et al., 2017). The survey consisted of a nationally representative sample of approximately 15 000 selected dwelling units (NDoH et al., 2017). Of the 13 000 occupied households, data was collected in face-to-face interviews by trained interviewers from 11 000 households (NDoH et al., 2017). There was a household response rate of 83%, and the response rate of eligible women (ages 15-49) was 86% (NDoH, Stats SA, SAMRC & ICF, 2019; NDoH et al., 2017)

3.4) Sample Design

The Census 2011 enumeration areas (EAs), were used to create the Statistics South Africa Master Sample Frame (MSF). The Statistics South Africa MSF was used as the sampling frame for the South Africa Demographic and Health Survey 2016 (SADHS 2016). "In the MSF, EAs of manageable size were treated as primary sampling units (PSUs), whereas small neighbouring EAs were pooled together to form new PSUs, and large EAs were split into conceptual PSUs" (NDoH et al., 2019:1; NDoH et al., 2017:3). Details regarding the approximate "number of residential dwelling units (DUs)" in each primary sampling unit and; details regarding the geographic type, whether urban, farm or traditional, was included in the frame

There are nine provinces within South Africa. The sample design of the SADHS 2016 provides "estimates of key indicators for the country as a whole, for urban and non-urban areas separately, and for each of the nine provinces in South Africa" (NDoH et al., 2019:1; NDoH et al., 2017:3). Sampling strata of twenty-six was provided as a result of stratifying each province into three different areas; urban, farm and traditional. The South Africa Demographic and Health Survey 2016 had followed a stratified sample design that was two stages. The first stage of the sample design was with a "probability proportional to size (PPS)" sampling of primary sampling units (PSUs), the second stage was a "systematic sampling of the dwelling units" (DUs) (NDoH et al., 2019:1; NDoH et al., 2017:3). To establish the measure of size of the primary sampling units (PSU), the Census 2011 dwelling unit count was used. "A total of 750 PSUs was selected from the 26 sampling strata, yielding 468 selected PSUs in urban areas, 224 PSUs in traditional areas, and 58 PSUs in farm areas (squared)" (NDoH et al., 2019:1-2; NDoH et al., 2017:3).

3.5) Non-Response

According to the SADHS (2016), a total of 750 primary sampling units that were used for the study, however, there were four primary sampling units that were removed from the sample, among the four, two were dropped due to refusals, making the units inaccessible. Refusal rates in the data was represented by the number nine.

3.6) Weighting Measures

"For the SADHS 2016, the survey sample is representative at the national and provincial levels, and for urban and non-urban areas" (NDoH et al., 2019: xxviii). In each of the nine provinces in South Africa, the women that are surveyed need to contribute to the size of the national (total) sample "in proportion to the size of the province" (NDoH et al., 2019: xxviii), this is required to create statistics that represents all nine provinces and all of South Africa. However, the problem arises when there are small populations in certain provinces this results in the "sample allocated in proportion to each province's population not including sufficient women from each province for analysis" (NDoH et al., 2019: xxviii). The main solution to this problem is oversampling provinces that have small populations. In addition to this to achieve or create statistics that represents South Africa, in the sample the distribution of women needs to be mathematically adjusted or "weighted" in order to "resemble the true distribution in South Africa" (NDoH et al., 2019: xxviii).

The data is weighted using:

svyset[pweight=V005], psu(V021) singleunit(certainty) strata(V022)

3.7) Variable Description and Measurement

3.7.1) Sample Demographics

The demographics of the sample include the mother's age at the time of the survey, mother's occupation, educational attainment, place of residence and marital status.

<u>Sample Demographics on Stata:</u>

Table 3.1: Sample Demographics

Definition	Codes	Categories
Mother's age		
Age in 5-year groups	V013	1-"15-19" 2-"20-24" 3-"25-29" 4-"30-34" 5-"35-39" 6-"40-44" 7-"45-49"
Mother's Occupation		
Respondent's occupation grouped	V717	0-"Not working" 1"Professional/ technical/ managerial" 2-"Clerical" 4-"Agricultural-self employed" 5-"Agricultural – unskilled" 6-"Household and domestic" 7-"Services" 8- "Skilled manual" 9-"Unskilled manual" 98- "Don't know"
clean variables to remove "don't know" & generate variable "mothers_occupation" to recategorize similar variables		
Respondent's occupation grouped	*Mothers_occupation*	*0-"Not working"* *1"Professional/ technical/ managerial"* *2-"Clerical"* *4-"Agricultural - self-employed & agricultural unskilled"* *6-"Household and domestic"* *7-"Services"* *8- "Skilled manual"* *9-"Unskilled manual"*
Education		
highest education level	*V106*	*0-"no education"* *1-"primary"* *2-"secondary"* *3-"tertiary"*

Definition	Codes	Categories
Place of Residence		
Type of place of residence	*V025*	*1-"Urban"* *2-"Rural"*
Marital Status		
Current marital status	*V501*	*0-"Never in union"* *1-"Married"* *2-"Living with partner"* *3-"Widowed"* *4-"Divorced"* *5-"No longer living together/separated"*
generate variable marital_status to recategorize similar variables		
Current marital status	*Marital_status*	*0-"Never in union"* *1-"Married"* *2-"Living with partner"* *3-"Widowed/ divorced/ separated"*

3.7.2) Dependent Variables

This research seeks to examine household water treatment and diarrhoea in children under-five. Variables in the SADHS (ZAKR71FL) dataset pertaining to children was used to profile diarrhoea in children. The dependent variable was any reported diarrhoea in children under five (10.3% of 3444 children) and anything done to water to make it safe to drink– from DHS report (NDoH et al., 2019).

<u>Dependent variables on Stata:</u>

Table 3.2: Dependent variables

Definition	Codes	Categories
Had diarrhoea		
Had diarrhoea recently	H11	0-"No" 1-"yes, last 24 hours" 2-"yes, last two weeks" 8- "don't know"
*clean variables to remove "don't know" *		
Had diarrhoea recently	*H11*	*0 "No"* *1"yes, last two weeks"*
Water treatment		
Do anything to water to make safe to drink	SH107	0-"No" 1-"Yes, always" 2-"Yes, sometimes" 8-"Don't know"
clean variables to remove "don't know" & combine		
Do anything to water to make safe to drink	*SH107*	*0-"No"* *1-"Yes, always/sometimes"*

3.7.3) Independent Variables

3.7.3.1) Key Independent Variables

Key independent variables on Stata:

Table 3.3: Key independent variables

Definition	Codes	Categories
Water interruptions		
Water interruptions	*HV201A*	*0-"No, not interrupted for a full day"* *1-"Yes, interrupted for a full day or more"*
Type of water treatment		
water usually treated by boil	*HV237A*	*0-"No"* *1-"yes*
water usually treated by add bleach/chlorine	*HV237B*	*0-"No"* *1-"yes"*
water usually treated by strain through a cloth	*HV237C*	*0-"No"* *1-"yes"*
water usually treated by use water filter	*HV237D*	*0-"No"* *1-"yes"*
water usually treated by solar disinfection	*HV237E*	*0-"No"* *1-"yes"*
water usually treated by let it stand and settle	*HV237F*	*0-"No"* *1-"yes"*
water usually treated by other	*HV237X*	*0-"No"* *1-"yes"*

3.7.3.2) Other Independent Variables

The environmental factors were the proximate determinants such as toilet facilities and sources of water. Other personal illness control variables were handwashing and disposal of stools. The socio-economic factors were the distal determinates of child mortality, such as the mother's education, occupation and household income/wealth. The demographic factors were maternal age, marital status, place of residence (rural or urban).

Other Independent Variables on Stata

Environmental factors:

Table 3.4: Environmental factor variables

Definition	Codes	Categories
Source of drinking water		
Source of drinking water	HV201	11-" Piped into dwelling" 12-"Piped to yard/plot" 13-"Piped to neighbour" 14-"Public tap/standpipe" 21-"Tube well or borehole" 31"-Protected well" 32-"Unprotected well" 41-"Protected spring" 42-"Unprotected spring" 43"River/dam/lake/ponds/stream/canal" 51-"Rainwater" 61-"Tanker truck" 62-"Cart with small tank" 71-"Bottled water" 96-"Other"
generate variable source_drinkingwater to recategorize similar variables		
Source of drinking water	*source_drinkingwater*	*11-" Piped into dwelling"* *12-"Piped to yard/plot"* *13-"Piped to neighbour"* *14-"Public tap/standpipe"* *21-"Tube well or borehole"* *31-"non-piped sources & other"* *71-"Bottled water"*
Shared toilet		
Toilet facilities shared with other households	V160	0-"No" 1-"Yes" 2-"Not a dejure resident"
Clean variable to remove "not a dejure resident"		
Toilet facilities shared with other households	*V160*	*0-"No"* *1-"Yes"*
Type of toilet		
Type of toilet facility	*HV205*	*11-"Flush to piped sewer system"* *12-"Flush to septic tank"* *13-"Flush to pit latrine"* *14-"Flush to somewhere else"* *15-"Flush, don't know where"* *21-"Ventilated Improved Pit latrine"* *22-"Pit latrine with ventilation pipe"* *23-"Pit latrine without ventilation pipe"* *31-" No facility/bush/field"* *41-"Composting toilet"* *42-"Bucket toilet"* *44-"Chemical toilet"* *96-"Other"*

Personal illness control:

Table 3.5: Personal illness control variables

Definition	Codes	Categories
Disposal of stools		
Disposal of youngest child's stool when not using toilet	*V465*	*1-"Used toilet/latrine"* *2-"Put/rinsed in latrine/toilet"* *3-"Put/rinsed into drain or ditch"* *4-"Throw into garbage"* *5-"Buried"* *9-"Left in the open/not disposed of"* *96-"Other"*
Handwashing		
generate handwashing variable using HV230B & HV232		
Handwashing	*handwashing (HV230B & HV232)*	*1-"water not available"* *2-"only water available"* *3-"water & soap/detergent available"*

Socio-economic variables:

Table 3.6: Socio-economic variables

Definition	Codes	Categories
Mother's education		
highest education level	*V106*	*0-"no education"* *1-"primary"* *2-"secondary"* *3-"tertiary"*
Mother's occupation		
Respondent's occupation grouped	*Mothers_occupation*	*0-"Not working"* *1"Professional/ technical/ managerial"* *2-"Clerical"* *4-"Agricultural - self-employed & agricultural unskilled"* *6-"Household and domestic"* *7-"Services"* *8- "Skilled manual"* *9-"Unskilled manual"*
Household income/ wealth		
Wealth index combined	*V190*	*1-"Poorest"* *2-"Poorer"* *3-"Middle"* *4-"Richer"* *5-"Richest"*

Wealth Index:

According to NDoH et al. (2019), wealth index is created by giving households scores based on the variety and number of consumer goods they possess, the consumer goods ranges from "a television to a bicycle or car, and housing characteristics such as source of drinking water, toilet facilities, and flooring materials" (NdoH et al., 2019:14). The principal component analysis is used to derive the scores. "National wealth quintiles are compiled by assigning the household score to each usual (de jure) household member, ranking each person in the household population by her or his score, and then dividing the distribution into five equal categories, each comprising 20% of the population" (NDoh et al., 2019:14).

The urban households in South Africa are more likely to fall into the higher wealth quintiles and the "non-urban (rural) households are more likely to fall into the lower wealth quintiles" (NDoH et al., 2019:14).

Demographic variables:

Table 3.7: Demographic variables

Definition	Codes	Categories
Maternal age at first birth		
Age of respondent at first birth	V212	9 to 42
generate variable agecat to group ages		
Age at first birth grouped	*agecat*	*1-"9-17"* *2-"18-25"* *3-"26-33"* *4-"34-42"*
Marital status		
Current marital status	*Marital_status*	*0-"Never in union"* *1-"Married"* *2-"Living with partner"* *3-"Widowed/ divorced/ separated"*
Place of residence		
Type of place of residence	*V025*	*1-"Urban"* *2-"Rural"*

3.8) Data Analysis Methods

This study was a secondary data analysis of the SADHS 2016 dataset to measure the degree to which certain factors are associated with water interruptions, household water treatment and diarrhea among children under-five. Stata IC version 13.0 was used for data analysis. Survey commands or procedures (SVY) was used for procedures in the data analysis. Firstly, demographics of the sample (women age 15-49) were presented, including age, mother's occupation, highest education level, place of residence and marital status; followed by a report on the prevalence of diarrhea among children under five years. Descriptive statistics were then reported for water related and stool disposal variables, including water interruptions (HV201A), water treatment (do anything to water to make safe to drink) (SH107), handwashing (*handwashing)* and source of drinking water (*source_drinkingwater)*; as well as the type of toilet (HV205), shared toilet facilities (V106) and the disposal of the youngest child's stool (V465).

Following this was a bivariate analysis, employing the use of crosstabs to investigate the influence of independent variables on the child under five years old having diarrhea and to investigate the influence of independent variables on water treatment at a household level. Chi-square tests were carried out in order to test for significant associations. Significant variables of the bivariate analysis (where the p-value was less than 0.05) were used in the unadjusted logistic regression analysis, variables that proved to be significant were then added to multivariate logistic regression models, "diarrhea" being the dependent variable in one, and "do anything to water to make safe to drink" being the dependent variable in the other. Results were then presented as odds ratios.

The equation for logistic regression is given below:

$$Ln\ (P_i/1{-}P_I) = \propto + \beta_1\ X_{1i} + \ \beta_2 X_{2i} + \cdots + \beta_k X_{ki}$$

Pi – The chance of respondents reporting their child has had diarrhea & the chance of participants reporting they do something to the water to make it safe to drink, dependent variable (odds ratio)

βk – Dependent variables regression coefficients (water interruptions, education, wealth, place of residence, occupation, marital status, handwashing, source of drinking water etc.)

3.9) Ethical considerations

The Demographic and Health Surveys (DHS) program had provided authorisation and ethical approval for the SADHS questionnaire and study protocols. It was stated that "The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified". The respondents were informed and addressed accordingly. Ethical approval for the secondary analysis of the SADHS data for the purposes of this research was obtained from the Humanities and Social Sciences Research Ethics Committee (HSSREC) at the University of Kwa-Zulu Natal.

3.10) Validity, Reliability and Rigour

In quantitative research, validity is the extent to which a concept is or can be accurately measured (Heale & Twycross, 2015). Validity can be categorised as content validity, which focuses on whether the instrument used covers the content that it should with respect to the variable; and, construct validity, this focuses on whether inferences can be drawn about test scores related to the concept being researched (Heale & Twycross, 2015). In this research, both content and construct validity were achieved. Reliability relates to consistency and due to this research being a secondary data analysis the responses and the way in which the data was collected for the SADHS makes it reliable, as well as the fact that the SADHS 2016 was the third Demographic and Health Survey to be conducted in South Africa, increases the reliability and making it more current. However, it is important to consider that responses are never 100% accurate, valid or reliable, but they can be close to accurate, valid and reliable. Statistical methods of analysis were used for this research and therefore this research was thorough (Heale & Twycross, 2015).

3.11) Conclusion

This chapter has outlined the methodology that was used for this secondary data analysis study. The primary source of the data, the SADHS (2016), was discussed at length, followed by an explanation of the methods of analysis utilized. The dependent and independent variables were highlighted; ethical considerations as well as the reliability, validity and rigour were provided.

CHAPTER FOUR

RESULTS

4.1) Introduction

This chapter will present the results of the secondary data analysis. It will begin by providing the demographics of the sample, followed by a report of the descriptive statistics related to water and stool disposal variables. The results from the bivariate analysis will then be presented followed by the results of an unadjusted logistic regression analysis and a multivariate logistic regression analysis, for diarrhoea and water treatment at a household level, respectively.

4.2) Demographics of the sample

Table 4.1: Demographics of sample (Women age 15-49)

Variable	Weighted Percentage	95% Confidence interval for %
Mother's Age (5-year groups) (n=3548)		
15-19	5.24	4.42 - 6.20
20-24	23.64	21.58 - 25.83
25-29	28.7	26.38 - 31.14
30-34	21.27	19.16 - 23.54
35-39	13.67	12.24 - 15.25
40-44	6.21	5.24 - 7.35
45-49	1.25	0.85 - 1.82
Mother's occupation (n=3409)		
Not working	66.38	63.72 - 68.94
Professional/technical/managerial	7.15	5.76 - 8.84
Clerical	5.41	4.36 - 6.69
Agricultural	1.42	0.94 - 2.13
Household and domestic	3.72	2.86 - 4.84
Services	7.09	5.92 - 8.47
Skilled manual	1.31	0.93 - 1.85
Unskilled manual	7.49	6.26 - 8.94
Highest education level (n=3548)		
No education	1.39	0.92 - 2.1
Primary	8.96	7.44 - 10.77
Secondary	78.53	76.2 - 80.68
Tertiary	11.11	9.25 - 13.27
Place of residence (n=3548)		
Urban	63.86	60.63 - 66.97
Rural	36.14	33.03 - 39.37

Variable	Weighted Percentage	95% Confidence interval for %
Marital status (n=3548)		
Never in union	50.83	48.14 - 53.51
Married	27.33	24.81 - 30
Living with partner	18.01	15.97 - 20.25
Widowed/ divorced/ separated	3.83	3.01 - 4.86

The data for the analysis was taken from the SADHS 2016, child and household datasets. It focused mainly on the response of mothers between the ages of 15-49. The sample size was n=3548, however, respondent's occupation had a sample size of n=3409 after cleaning the data and removing "don't know". All percentages in table 4.1 are weighted. The age category 25-29 had the highest number of women, making up over a quarter (28.7%) of the women. The age category 45-49 had the lowest number of women, making up just 1.25% of the women. Employment status of women using the variable "Respondent's occupation grouped" showed two thirds (66.38%) of the women from the sample were not working/unemployed and from those that were working/employed (33.59%), only 7.15% had professional, technical or managerial jobs.

The highest education level achieved by over three quarter (78.53%) of the women from the sample, was secondary level education; and only 11.11% of women had furthered their education and achieved a "higher" (tertiary) level of education. Almost two thirds (63.86%) of the women from the sample were resident in urban areas, half (50.83%) were never in a union/married, just over a quarter (27.33%) were married, and 18.01% were living with their partner/cohabiting.

4.3) Prevalence of Diarrhoea

Table 4.2: Prevalence of diarrhoea among children under five years

Had diarrhoea recently	Weighted Percentage (n=3241)	95% Confidence interval for %
No	88.99	87.41 - 90.39
Yes, last two weeks	11.01	9.61 - 12.59

In South Africa, diarrhoea remains to be a significant cause of child morbidity and mortality (SADHS, 2016). In the last two weeks before the SADHS 2016 survey, out of a sample size of n=3241 (after cleaning variable to remove missing data), 11.01% of children under the age of five had diarrhoea (weighted percentage).

4.4) Descriptive Statistics of Water Related and Stool Disposal Variables

Table 4.3: Descriptive statistics of water related and stool disposal variables

Response	Unweighted Frequency	Weighted Percentage	95% Confidence interval for %
Water not available for at least a day in the last two weeks			
No, not interrupted	1899	66.06	62.58 - 69.38
Yes, interrupted	1143	33.94	30.62 - 37.42
Do anything to water to make safe to drink			
No	3224	93.33	91.99 - 94.45
Yes, always/sometimes	317	6.67	5.546 - 8.011
Handwashing			
No water	628	19.57	16.91 - 22.53
Only water	1182	36.15	33.19 - 39.22
Water and soap/ detergent	1249	44.28	41.17 - 47.43
Source of drinking water			
Piped into dwelling	1238	39.76	36.04 - 43.62
Piped into yard/plot	967	27.52	24.17 - 31.15
Piped to neighbour	130	3.79	2.17 - 6.56
Public tap/ standpipe	589	14.94	12.42 - 17.88
Tube well or borehole	127	2.58	1.92 - 3.46
Non-piped sources and other	459	10.82	8.82 - 13.22
Bottled water	29	0.58	0.31 - 1.06
Type of toilet			
Flush to piped sewer system	1598	50.85	46.42 - 55.26
Flush to septic tank	58	1.45	0.91 - 2.31
Flush to pit latrine	30	1.26	0.46 - 3.44
Flush to somewhere else	15	0.40	0.19 - 0.85
Flush, don’t know where	5	0.07	0.02 - 0.22
Ventilated Improved Pit latrine	264	6.23	5.09 - 7.59
Pit latrine with ventilation pipe	423	9.96	8.31 - 11.89
Pit latrine without ventilation pipe	917	22.93	19.94 - 26.22
No facility/bush/field	139	3.53	2.58 - 4.81
Composting toilet	17	0.85	0.40 - 1.80
Bucket toilet	70	1.82	1.09 - 3.04
Chemical toilet	10	0.62	0.19 - 1.98
Other	2	0.03	0.01 - 0.14
Toilet facilities shared with other households			
No	2636	77.18	73.87 - 80.18
Yes	624	22.82	19.82 - 26.13
Disposal of youngest child’s stool when not using toilet			
Used toilet/latrine	40	4.68	2.69 - 8.029
Put/rinsed in latrine/toilet	197	11.47	9.11 - 14.35
Put/rinsed into drain or ditch	64	4.19	2.89 - 6.03
Throw into garbage	1218	77.07	73.14 - 80.57
Buried	45	1.99	1.37 - 2.88

Response	Unweighted Frequency	Weighted Percentage	95% Confidence interval for %
Disposal of youngest child's stool when not using toilet			
Left in the open/not disposed of	7	0.33	0.12 - 0.90
Other	7	0.28	0.13 - 0.62

Table 4.3 reports the descriptive statistics of water related variables such as water interruptions, water treatment at a household level, handwashing and the source of drinking water; as well as the descriptive statistics of stool disposal variables, such as the type of toilet, shared toilet facilities and the disposal of the youngest child's stool. All frequencies in the above table are unweighted accompanied by the weighted percentages and confidence intervals. One third (33.94%) had experienced water interruptions for a day or more in the two weeks before the survey. In terms of water treatment, 93.33% did not use any household water treatment methods to make the water safe to drink. One in five (19.57%), had no water available to wash their hands and just over two fifths (44.28%) had both water and soap/detergent available to wash their hands. When looking at the source of the drinking water, two fifths (39.76%) had their water piped into their dwelling and 10.82% collected their drinking water from non-piped sources and other. From the various type of toilet facilities, half (50.85%) used a toilet that flushed into a piped sewer and just over three-quarters (77.18%) used toilet facilities shared with other households. When not using a toilet to dispose of the youngest child's stool in a household, just over three-quarters (77.07%) throw it into the garbage and only 4.68% used a toilet or latrine.

4.5) Bivariate Analysis: Diarrhoea

Table 4.4: Bivariate analysis: Had diarrhoea recently?

Variable	X^2	P-value
Water variables		
Water not available for at least a day last two weeks	41.06	0.000
Water usually treated by: boil	0.99	0.404
Water usually treated by: add bleach/ chlorine	0.22	0.577
Water usually treated by: strain through a cloth	0.21	0.726
Water usually treated by: use water filter	0.24	0.749
Water usually treated by: solar disinfection	0.10	0.725
Water usually treated by: let it stand and settle	1.97	0.082
Water usually treated by: other	0.31	0.443
Environmental variables		
Source of drinking water	31.77	0.001
Toilet facilities shared with other households	0.22	0.723
Type of toilet facility	26.33	0.311
Personal illness control		
Disposal of youngest child's stools when not using toilet	3.61	0.747
Handwashing	15.10	0.012
Socio-economic variables		
Highest educational level	11.15	0.047
Mother's occupation (grouped)	12.70	0.314
Wealth index combined	24.76	0.014
Demographic variables		
Age at first birth (grouped)	2.58	0.643
Marital status	20.75	0.005
Type of place of residence	9.47	0.019

Table 4.4 presents the Chi-square (X^2) test for significance results of the bivariate analysis. It shows the relationship between the relevant water, environmental, personal illness control, socio-economic and demographic variables and having had diarrhoea recently. Variables which showed significance (p-value < 0.05), such as water interruptions (water not available for at least a day in the last two weeks) (p-value = 0.000), source of drinking water (p-value = 0.001), handwashing (p-value = 0.012), education (highest education level) (p-value = 0.047), wealth (wealth index combined) (p-value = 0.014), marital status (p-value = 0.005) and place of residence (p-value = 0.019) was used in the unadjusted logistic regression analysis for diarrhoea.

4.6) Unadjusted Logistic Regression Analysis: Diarrhoea

Table 4.5: Unadjusted logistic regression: Had diarrhoea recently?

Variable	Unadjusted OR (95% CI)	P-value
Water not available for at least a day in the last two weeks		
No, not interrupted for a full day	1.00	
Yes, interrupted for a full day or more	2.16 (1.57-2.98)	0.000
Source of drinking water		
Piped into dwelling	1.00	
Piped to yard/plot	1.25 (0.87-1.81)	0.229
Piped to neighbour	3.31 (1.77-6.19)	0.000
Public tap/standpipe	1.46 (0.93-2.29)	0.101
Tube well or borehole	0.84 (0.40-1.76)	0.644
Non-piped sources & other	1.33 (0.87-2.04)	0.190
Bottled water	1.90 (0.57-6.40)	0.298
Handwashing		
Water not available	1.00	
Only water available	0.65 (0.44-0.95)	0.026
Water & soap/detergent available	0.56 (0.38-0.81)	0.003
Highest education level		
No education	1.00	
Primary	1.53 (0.61-3.87)	0.364
Secondary	0.90 (0.39-2.09)	0.814
Higher	0.76 (0.30-1.93)	0.568
Wealth index combined		
Poorest	1.00	
Poorer	1.21 (0.81-1.79)	0.355
Middle	0.69 (0.46-1.04)	0.080
Richer	0.70 (0.41-1.17)	0.172
Richest	0.54 (0.31-0.94)	0.029
Marital status		
Never in union	1.00	
Married	0.76 (0.54-1.07)	0.120
Living with partner	1.56 (1.10-2.22)	0.013
Widowed/ divorced/separated	0.79 (0.37- 1.69)	0.549
Type of place of residence		
Urban	1.00	
Rural	1.42 (1.06-1.90)	0.019

According to the unadjusted OR:

Water interruptions proved to be particularly significant with having diarrhoea recently. Those that reported water being interrupted for a full day or more in the two weeks before the survey, were 116% more likely to have reported their children having had diarrhoea, than those that had reported not having interruptions in the two weeks before the survey. Individuals that collected drinking water/drank water piped to their neighbour were 231% more likely to have reported their children having had diarrhoea recently than those that collected drinking water/drank water piped into the dwelling. With regards to handwashing those with only water available to wash their hands were 35% less likely to have reported their children having had diarrhoea recently than those that reported not having water available. Those with water and soap/detergent available to wash their hands were 44% less likely to have reported their children having had diarrhoea recently than those that reported not having water available. The richest individuals were 46% less likely to have reported their children having had diarrhoea recently than the poorest individuals. Those reported living with a partner were 56% more likely to have reported their children having had diarrhoea recently than those that were never in a union. Those that resided in rural areas were 42% more likely to have reported their children having had diarrhoea recently than those that resided in urban areas

4.7) Adjusted Logistic Regression Analysis: Diarrhoea

Table 4.6: Multivariate Logistic Regression Model: Had diarrhoea recently?

Variable	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	P-value
Water not available for at least a day in the last two weeks			
No, not interrupted for a full day	1.00	1.00	
Yes, interrupted for a full day or more	2.16 (1.57-2.98)	2.14 (1.48-3.09)	0.000
Source of drinking water			
Piped into dwelling	1.00	1.00	
Piped to yard/plot	1.25 (0.87-1.81)	1.03 (0.64-1.66)	0.902
Piped to neighbour	3.31 (1.77-6.19)	2.09 (0.91-4.78)	0.081
Public tap/standpipe	1.46 (0.93-2.29)	0.98 (0.47-2.01)	0.946
Tube well or borehole	0.84 (0.40-1.76)	0.62 (0.23-1.65)	0.339
Non-piped sources & other	1.33 (0.87-2.04)	1	-
Bottled water	1.90 (0.57-6.40)	1.01 (0.33-3.10)	0.987
Handwashing			
Water not available	1.00		
Only water available	0.65 (0.44-0.95)	0.71 (0.48-1.07)	0.104
Water & soap/detergent available	0.56 (0.38-0.81)	0.76 (0.47-1.21)	0.240
Highest education level			
No education	1.00	1.00	
Primary	1.53 (0.61-3.87)	3.25 (0.81-13.00)	0.095
Secondary	0.90 (0.39-2.09)	1.86 (0.49-7.11)	0.366
Higher	0.76 (0.30-1.93)	2.20 (0.54-9.04)	0.273
Wealth index combined			
Poorest	1.00	1.00	
Poorer	1.21 (0.81-1.79)	1.16 (0.67-2.01)	0.604
Middle	0.69 (0.46-1.04)	0.77 (0.43-1.39)	0.387
Richer	0.70 (0.41-1.17)	1.03 (0.51-2.08)	0.937
Richest	0.54 (0.31-0.94)	0.78 (0.35-1.73)	0.540
Marital status			
Never in union	1.00	1.00	
Married	0.76 (0.54-1.07)	0.72 (0.47-1.10)	0.130
Living with partner	1.56 (1.10-2.22)	1.58 (1.06-2.34)	0.023
Widowed/ divorced/ separated	0.79 (0.37- 1.69)	0.81 (0.33-1.99)	0.646
Type of place of residence			
Urban	1.00	1.00	
Rural	1.42 (1.06-1.90)	0.99 (0.64-1.53)	0.965

*Missing value on table is a result of collinearity

<u>According to the adjusted OR:</u>

Water interruptions and marital status (living with a partner) proved to be particularly significant with having diarrhoea recently. Those that reported water being interrupted for a full day or more in the two weeks before the survey, were 114% more likely to have reported their children having had diarrhoea, than those that had reported not having interruptions in the two weeks before the survey. Those reported living with a partner were 58% more likely to have reported their children having had diarrhoea recently than those that were never in a union.

4.8) Bivariate Analysis: Water treatment

Table 4.7: Bivariate analysis: Do anything to water to make safe to drink?

Variable	X^2	P-value
Socio-economic variables		
Highest educational level	27.91	0.000
Mothers occupation (grouped)	65.05	0.000
Wealth index combined	47.18	0.000
Demographic variables		
Age at first birth (grouped)	1.06	0.841
Marital status	8.81	0.263
Type of place of residence	0.45	0.623

Table 4.7 presents the Chi-square (X^2) test for significance results of the bivariate analysis. It shows the relationship between the relevant socio-economic and demographic variables and water treatment at a household level (do anything to water to make safe to drink). Variables which showed significance (p-value < 0.05) such as education (highest education level) (p-value = 0.000), occupation (mother's occupation) (p-value = 0.000) and wealth (wealth index combined) (p-value = 0.000) was used in the unadjusted logistic regression analysis for water treatment at a household level.

4.9) Unadjusted Logistic Regression Analysis: Water Treatment

Table 4.8: Unadjusted Logistic Regression: Do anything to water to make safe to drink?

Variable	Unadjusted OR (95% CI)	P-value
Highest education level		
No education	1.00	
Primary	3.31 (0.41-26.93)	0.264
Secondary	3.74 (0.51-27.57)	0.195
Higher	8.49 (1.09-66.15)	0.041
Mother's occupation grouped		
Not working	1.00	
Professional/technical/managerial	2.02 (0.83-4.93)	0.120
Clerical	2.59 (1.40-4.80)	0.003
Agricultural	1	-
Household and domestic	1.53 (0.67-3.48)	0.313
Services	3.58 (2.16-5.93)	0.000
Skilled manual	1.08 (0.36-3.23)	0.889
Unskilled manual	0 .69 (0.37-1.29)	0.244
Wealth index combined		
Poorest	1.00	
Poorer	0.64 (0.37-1.14)	0.130
Middle	1.33 (0.78-2.28)	0.291
Richer	1.60 (0.94-2.73)	0.086
Richest	2.65 (1.47-4.79)	0.001

*Missing value on table is a result of collinearity

According to the unadjusted OR:

Education, occupation and wealth index was particularly significant with treating water at a household level. Those that had completed a higher level of education were 749% more likely to report having done something to the water to make it safe to drink than those with no education. Individuals with a clerical occupation were 159% more likely to report having done anything to the water to make it safe to drink than individuals who were not working. Individuals that worked in services were 259% more likely to report having done anything to the water to make it safe to drink than individuals who were not working. The richest individuals were 165% more likely than the poorest individuals to have reported having done anything to the water to make it safe to drink

4.10) Adjusted Logistic Regression Analysis: Water treatment

Table 4.9: Multivariate Logistic Regression Model: Do anything to water to make safe to drink?

Variable	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	P-value
Highest education level			
No education	1.00	1.00	
Primary	3.31 (0.41-26.93)	3.19 (0.37-27.27)	0.289
Secondary	3.74 (0.51-27.57)	2.51 (0.34-18.48)	0.367
Higher	8.49 (1.09-66.15)	3.74 (0.48-28.93)	0.206
Mother's occupation grouped			
Not working	1.00	1.00	
Professional/technical/managerial	2.02 (0.83-4.93)	1.25 (0.48-3.21)	0.650
Clerical	2.59 (1.40-4.80)	1.93 (1.04-3.57)	0.036
Agricultural	1	1	-
Household and domestic	1.53 (0.67-3.48)	1.65 (0.72-3.79)	0.240
Services	3.58 (2.16-5.93)	3.12 (1.82-5.33)	0.000
Skilled manual	1.08 (0.36-3.23)	1.06 (0.37-3.07)	0.912
Unskilled manual	0 .69 (0.37-1.29)	0.70 (0.37-1.33)	0.278
Wealth index combined			
Poorest	1.00	1.00	
Poorer	0.64 (0.37-1.14)	0.58 (0.32-1.05)	0.074
Middle	1.33 (0.78-2.28)	1.15 (0.66-1.99)	0.626
Richer	1.60 (0.94-2.73)	1.33 (0.75-2.37)	0.329
Richest	2.65 (1.47-4.79)	1.68 (0.86-3.26)	0.127

*Missing value on table is a result of collinearity

<u>According to the adjusted OR:</u>

Mother's occupation was particularly significant with treating water at a household level. Individuals with a clerical occupation were 93% more likely to report having done anything to the water to make it safe to drink than individuals who were not working. Individuals that worked in services were 212% more likely to report having done anything to the water to make it safe to drink than individuals who were not working.

4.11) Conclusion

In the above chapter, the descriptive statistics, bivariate analysis and logistic regression (unadjusted and adjusted) results were provided and explained. The bivariate analysis and logistic regression results were provided for the two dependent variables. Diarrhoea, being the first dependent variable, where water interruptions, environmental (source of drinking water), personal illness control (handwashing), socio-economic (education and wealth) and demographic (marital status and place of residence) variables proved to be significant. Water treatment at a household level, “anything done to water”, being the second dependent variable, where socio-economic (education, occupation and wealth) variables proved to be significant

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1) Introduction

The following chapter will begin by discussing the results of the first dependent variable "had diarrhoea recently", highlighting any water variables. As well as any demographic, socioeconomic, environmental and personal illness control factors that proved to be significant. This is followed by a discussion on the results of the second dependent variable "anything done to water to make safe to drink" highlighting any socioeconomic and demographic factors that proved to be significant. The limitations and recommendations of the study will then be provided.

5.2) Factors Associated with Diarrhoea

5.2.1) Water Variables

Those reporting their water being interrupted for a full day or more in the two weeks before the survey, were 114% more likely to have reported their children having had diarrhoea, than those that had reported not having interruptions in the two weeks before the survey. This is consistent with the findings of Huntera et al. (2009), Yassin et al. (2006), Lechtenfeld (2012) & Roushdy & Sieverding (2016), who found that water interruptions increase the incidence and prevalence of diarrhoea among children under five. These results are particularly important given the increase in water interruptions experienced by South Africans, keeping in mind the Cape Town Water Crisis which took place between 2016-2018. Water interruptions could be a result of demand exceeding supply, the deterioration and breakdown of old pipes as well as the "illegal connections" to water pipes, (Yassin et al., 2006; Kapwata et al., 2018). As a result, the water becomes contaminated during periods of water shut down and causes diarrhoeal diseases if consumed without being treated at a household level (Adane et al., 2017; Hunter et al., 2005; Huntera et al., 2009; Yassin et al., 2006; Lechtenfeld, 2012; Roushdy & Sieverding, 2016; Kapwata et al., 2018).

In addition, from the identified household water treatment methods, none proved to be a significant predictor of having diarrhoea, however, letting the water stand and settle was close to significant in the bivariate analysis this may indicate that it is probably the most widely used household water treatment method, however, what is concerning is that it is considered, in various studies, to be the most ineffective HHWT method as well as a "pre-treatment" method (Edokpayi et al., 2018; Rosa & Clasen, 2010; Rosa, et al., 2016; Schutte et al., 2006).

5.2.2) Demographic variables

In the bivariate analysis of the demographic variables, place of residence and marital status were the only variables that proved to be significantly associated with diarrhea. Rural residents were 42% more likely to have reported their children having had diarrhoea recently than urban residents. This is consistent with the findings of Bogale et al. (2017), Kumi-Kyereme & Amo-Adje (2014) & Siziya et al. (2013), who found that the incidence and prevalence of diarrhoea is higher in rural areas and that it can be attributed to the wealth differences between the two areas, where the wealthy urban can afford better amenities than the rural poor and therefore achieve a higher level of hygiene, subsequently reducing the incidence of diarrhoea among children under five (Siziya et al., 2013). This is supported by NDoH et al. (2019) as it is stated that in South Africa, "urban households are more likely than non-urban households to fall into the higher wealth quintiles, while non-urban households are more likely to fall into the lower wealth quintiles" (NDoH et al., 2019:14). It can also be attributed to the lack of access to, and unavailability of, clean, safe drinking water, experienced by rural residents (Bogale et al, 2017).

Interestingly, marital status proved to be significant in both the unadjusted and multivariate logistic regression analysis, resulting in it being a significant predictor of diarrhoea among children under five. Those who reported living with a partner were 58% more likely to have reported their children having had diarrhoea recently than those that were never in a union. This is consistent with the findings of the World Family Map (2014), revealing that children exposed to the union instability of the mother, usually children born to mothers that have not remained in one union throughout her life, but have instead engaged in cohabiting partnerships (lived with the partner without being married to them), are more likely to be affected by a diarrhoeal disease. This is attributed to the nature of cohabiting relationships, it is often the youth that engage in cohabitation, using it as a precursor or an alternative to marriage, usually because they are not financially or emotionally equipped or ready for marriage (De Wet & Gumbo, 2016; Golub & Reid, 2015). The cohabiting partnership/ relationship tends to be very flexible and inconsistent and usually negatively affects any child involved as they become severely neglected; in addition, there is also an association between poverty and cohabitation, and as a result of the environmental conditions or circumstances of those living in poverty and cohabiting, coupled with parental neglect, children involved become vulnerable and the relationship directly affects the health of the child (Golub & Reid, 2015; Manning, 2015; World Family Map, 2014).

5.2.3) Socio-economic variables

Only household wealth proved to be significant in the unadjusted logistic regression analysis, with the richest individuals being 46% less likely to have reported their children having had diarrhoea recently, compared to those in the poorest quintile. These findings were consistent with those of Wyrsch et al. (1998), & Lartey et al. (2016), who showed that the incidence of diarrhoea among children under five was higher in low income households, and lower in high income households, because wealthier households can usually afford better amenities and facilities. None of the socio-economic variables proved to be significant in the multivariate logistic regression analysis.

5.2.4) Environmental variables

Among the environmental variables identified, source of drinking water was the only variable that proved to be significant in the bivariate analysis, individuals that collected drinking water/drank water piped to their neighbour being 231% more likely to have reported their children having had diarrhoea recently than those that collected drinking water/drank water piped into the dwelling. This can be attributed to the way in which individuals handle water that is being collected from their neighbour. It can be assumed that those who collect water piped to their neighbour, usually collect in large amounts to use over a period of time and not just for immediate consumption. As a result, the way in which the water is handled and stored thereafter will determine the quality of the water and its impact on child health (Clasen et al., 2015; Adane et al., 2017; Roushdy & Sieverding, 2016). Various studies reveal that collected water is subject to contamination if not stored in clean containers that can close, and if it is in a container without a pouring nozzle, very often the water is exposed to "hand-to-water transmission of pathogens" (Lechtenfeld, 2012:2), this results in an increase in the incidence and prevalence of diarrhoea among children under five (Adane et al., 2017; Roushdy & Sieverding, 2016).

5.2.5) Personal illness control variables

Handwashing proved to be the only significant illness control variable in the bivariate and unadjusted logistic regression analysis. Those with only water available to wash their hands were 35% less likely to have reported their children having had diarrhoea recently than those that reported not having water available; and t those with water and soap/detergent available to wash their hands were 44% less likely to have reported their children having had diarrhoea recently than those that reported not having water available. This finding is consistent with the findings of Bizuneh et al. (2017); Feleke et al. (2018), & Mohammed & Zungu, (2016).

5.3) Factors Associated with HHWT

5.3.1) Socio-economic variables

The socio-economic variables analysed were mother's education, mother's occupation and wealth index combined. The only variable that proved to be a significant predictor of employing water treatments at a household level in the bivariate, unadjusted logistic regression and multivariate logistic regression analysis, was mother's occupation. Mothers with a clerical occupation were 93% more likely to report having done something to the water to make it safe to drink than individuals who were not working. Those working in services were 212% more likely to report having done something to the water to make it safe to drink than individuals who were not working.

It is important to recognise how different occupational statuses affect the decision to treat water at a household level. Consideration needs to be given to the background of those working in clerical and service positions, it is possible that majority of these workers reside in places where they do not have access to safe sources of water or where the piped water being received cannot be trusted, and therefore would need to treat it at a household level prior to consumption. The results reveal that occupational status is a significant predictor of whether individuals treat their water at a household level. This finding is consistent with the findings of Birara et al. (2018).

In addition, mother's education and the wealth status of the household proved to be significant in the bivariate and unadjusted logistic regression analysis. Mothers with a completed higher (tertiary) level of education were 749% more likely to report having done something to the water to make it safe to drink than those with no education. The results reveal that educated individuals are more likely to employ a HHWT method, this is consistent with the findings of Geremew et al. (2018), Daniela et al. (2019), & Geremew & Damtew (2019), who found that the more educated individuals are, the likelihood of adopting a HHWT method is higher.

In terms of wealth, those in the richest wealth quintile were 165% more likely than the poorest individuals to have reported having done anything to the water to make it safe to drink. The results reveal that wealthy individuals are more likely to adopt a HHWT method, this is consistent with the findings of Geremew et al. (2018). The findings of Jones et al. (2007), revealed that the wealth status of individuals/households also determines the type of HHWT that would be adopted by a household, the inexpensive methods are adopted by the poorer households and the expensive methods are adopted by wealthier households. Although in this study, education and wealth may not be significant predictors of treating water at a household level, both contribute to the decision to employ a HHWT (Geremew et al., 2018; Geremew & Damtew, 2019)

5.4) Theoretical Framework

Mosley and Chen's analytical framework for the study of child survival distinguishes between the socio-economic and proximate determinants of child mortality. The framework posits that socio-economic determinants (distal determinants) of child mortality have to operate indirectly through proximate determinants (intermediate variables) or biological mechanisms to influence the risk of mortality (Mosely & Chen, 1984; Ogada, 2012). In accordance with Mosley and Chen's framework, this study has investigated and identified a correlation between socio-economic factors (education; occupation; wealth), environmental (source of water; toilet facilities) and personal illness control (handwashing; stool disposal) and child morbidity/mortality as a result of diarrhoeal disease.

From the socio-economic factors, the results of the bivariate analysis reveal that there was a significant relationship between the mother's level of education and the child having had diarrhoea. In the framework, Mosley & Chen (1984) identify education as an "individual level variable" (Mosley & Chen, 1984:5). In addition, there was a significant relationship between wealth and the child having had diarrhoea, in the framework, wealth is identified as a "household level variable" (Mosley & Chen, 1984:5). There was a significant relationship between the source at which households obtain their drinking water and the child having had diarrhoea, in Mosley & Chen's framework, the source of drinking water is identified as an environmental contamination factor, which is known to "influence the rate of shift of healthy individuals towards sickness" (Mosley & Chen, 1984:3). There is also a significant relationship between handwashing and the child having had diarrhoea, in the framework, handwashing is identified as a personal illness control strategy, which is known to "influence the rate of illness (through prevention) and the rate of recovery (through treatment)" (Mosley & Chen, 1984:3).

“The purpose of the analytical framework in the study of child survival is to clarify our understanding of the many factors involved in the family’s production of healthy children in order to provide a foundation for formulating health policies and strategies” (Mosley & Chen, 1984:5). It is therefore important to recognise that in this study and various other studies, socio-economic, environmental and personal illness control factors influence child survival and do not exist and function exclusively.

5.5) Limitations

One limitation of this study was encountered with the SA Demographic and Health Survey 2016 data. During the analysis of the child and household datasets on STATA, errors were encountered due to singleton PSUs. Which result in only one PSU in a stratum, rendering the stratum insufficient to compute an estimation of its variance (STATA, 2020). In addition, another limitation to the study would be that two PSU’s were dropped as a result of refusals (SADHS, 2020). The solely quantitative nature of the study restricted the exploration of individuals perceptions and thoughts on household water treatment.

5.6) Recommendations

The increasing water interruptions experienced by South Africans prove to increase the incidence of diarrhoea among children under five, who are known to be “at highest risk of the morbidity and mortality associated with waterborne diseases” (Edokpayi et al., 2018). For this reason, interruptions need to be reduced to a minimum and there needs to be a reconsideration on the health effects assumed by receiving piped water (Lechtenfeld, 2012). A reduction in the frequency of interruptions, can be achieved by the regular inspection and maintenance of water pipes to ensure minimal breakage (Yassin et al., 2006). Households need to be informed on the dangers of piped water consumption following a water interruption.

Point-of-use or household water treatments have been recognized in various studies to effectively remove contaminants and improve water quality prior to consumption. However, POU/HHWT methods are not being utilized as widely as they should be, to some extent it is being undermined by many. To reduce the incidence of and prevent diarrhoea among children under five in South Africa, POU/HHWT should be employed alongside improved water handling and storage practices even by those that receive piped water (specifically after water interruptions), to ensure that the water is safe and clean prior to consumption. POU/HHWT should be promoted extensively alongside the dangers of consuming unsafe water, more knowledge needs to be spread on the need to employ water treatments at a point-of-use/household level.

5.7) Conclusion

The vast range of point-of-use/household water treatments have proved, in various studies, to be an effective, affordable way to ensure that water is safe for consumption by reducing unexpected contaminants and pathogens found in the water. Thereby, reducing the incidence of diarrhoea among children under five, who happen to be the most vulnerable to death by waterborne diseases. The study used secondary data from the South Africa Demographic and Health Survey 2016. This study explored two dependent variables, the first being children under five having diarrhoea and the second being employing any water treatment at a household level.

Objectives of the study were achieved through the application of a quantitative methodology in order to answer the research questions, which were related to water variables (water interruptions and treatment methods), socioeconomic (education, occupation and wealth), demographic (maternal age, marital status and place of residence), environmental (toilet facilities and source of water) and personal illness control variables (disposal of stools and handwashing) and its relationship with children under five having had diarrhoea recently. As well as, the impact of socioeconomic and demographic variables on employing any water treatment at a household level.

The results of the study revealed that water interruptions and marital status, specifically living with partner/cohabiting, are significant predictors of children under five having diarrhoea; and that occupation is a significant predictor of employing water treatment at a household level. Further research needs to be done on the occurrence of and reasons behind water interruptions as well as how cohabitation increases the likelihood of diarrhoea among children under five.

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