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Municipal water in South Africa: The relationship between access, quality and childhood diarrhoea.

Furzana Timol

207504147

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Supervisor: Professor Dori Posel

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Abstract

Access to drinking water is a basic human right. Water is also a vehicle for the transmission of a number of communicable diseases. To reduce the risk of disease, water accessed must also be of a good quality, from a reliable source and within close proximity to one's residence. This dissertation examines the relationship between water access, water quality, and child health as measured through the incidence of childhood diarrhoeal disease. Two sets of analyses are conducted using General Household Survey data supplied by Statistics South Africa. The first component uses bivariate analysis to explore changes in water access and water quality between 2006 and 2011 in relation to various water-related characteristics. The second component uses the 2011 data in multivariate probit models to predict the probability of childhood diarrhoeal disease. Findings of the study suggest that the source of piped water access and the self-reported quality of municipal water are not significant predictors of child health. Instead, the household's treatment of water accessed is significantly associated with a lower probability of diarrhoeal disease. This finding suggests that interventions to improve end-use treatment of drinking water may be effective in reducing the burden of childhood disease.

Declaration

I, Furzana Timol declare that

(i) The research reported in this dissertation, except where otherwise indicated, is my original work.

(ii) This dissertation/thesis has not been submitted for any degree or examination at any other university.

(iii) This dissertation/thesis does not contain other person's data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Signature: ______________________ Date: 28 November 2014

As the student's supervisor, I have approved this dissertation for submission.

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Acronyms and abbreviations

DWA	Department of Water Affairs[1]
DWAF	Department of Water Affairs and Forestry[1]
DWAS	Department of Water Affairs and Sanitation
GHS	General Household Survey
MDG	Millennium Development Goal
RDP	Reconstruction and Development Programme
SANS	South African National Standard
Stats SA	Statistics South Africa
UNAIDS	Joint United Nations Programme on HIV and AIDS
UNCESCR	United Nations Committee on Economic, Cultural and Social Rights
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

[1] The Department of Water Affairs and Forestry was reconstituted in 2009 to become the Department of Water Affairs.

Chapter One

1. Introduction

The investigation into the relationship between water quality, water access and child health is a complex task which requires a focused approach. The aim of this chapter is to frame this dissertation. To this end the chapter discusses background information, which allows the investigation to be situated in the current discourse on the topic. This chapter also includes the rationale for pursuing such an investigation, as well as the aims and objectives of the study. The last section outlines the structure of the dissertation.

1.1 Background

Water is one of the most basic human needs; thus access to water forms a fundamental human right. This human right is met through the realisation of universal access to sufficient, safe, accessible, and affordable water (United Nations, 2010). With increasing population size, particularly in developing countries, a greater strain is placed on existing public resources. This strain is particularly evident in South Arica, given the need for racial redress and rapid development, alongside the burden of HIV/AIDS. South Africa continues to have one of the highest prevalence rates of HIV/AIDS in the world (UNAIDS, 2013). This factor alone influences multiple components from government budget spending to family structures and biological interactions with other diseases. South Africa has also undergone a massive infrastructural transformation aimed at providing services to the majority of its population that had previously lacked access to services. As a result, by 2010, 93% of the population had access to piped water, which was provided by municipal authorities. This is a substantial increase from 59% prior to 1994 (Stats SA, 2011a). A crucial question is whether the increased access has been accompanied by efficient service delivery and good quality water, and whether this has been distributed amongst all persons in South Africa.

The threat of infectious diseases in developing countries is becoming increasingly prominent. Millions of children die each year, a large number of them from easily preventable diseases (UNICEF, 2012). A quarter of the global burden of disease is attributable to environmental risks such as pollution, built environment and climate change. For children, the proportion attributable to the environment is greater at 34%, translating to a five times greater loss of the disability adjusted life years for children compared to the population as a whole (Prüss-Üstün & Corvalan, 2007). Diarrhoeal disease is an example of an easily preventable disease that is transmitted through unsafe water.

Diarrhoea is the second leading cause of illness in children under the age of five years and disproportionately affects the most deprived children (UNICEF, 2012). It is estimated that 94% of diarrhoeal disease is caused by environmental factors than can be changed (Prüss-Üstün & Corvalan, 2007). In particular, 88% of the global incidence of diarrhoeal disease can be linked to substandard water quality, sanitation and hygiene practices alone (World Health Organization, 2002). It is estimated that by addressing these three causes of diarrhoeal disease, 6.3% of world-wide deaths and 9.1% of disability adjusted life years can be prevented (Prüss-Üstün, Bos *et al*. 2008). It is of further importance to address these causes, as the impact of disease during childhood can affect a person throughout their lifetime (Grantham-McGregor et al., 2007).

In South Africa, diarrhoea is the leading cause of under-five mortality with 21% of deaths being attributed to this easily preventative disease (Nannan et al., 2012). The contribution of this easily preventable disease to the under-five mortality rate is indicative of both access and equity to basic prevention and treatment (UNICEF, 2012a). In South Africa, the incidence of diarrhoea in those under the age of five has decreased from 138.0 per 1000 children in 2001 to 102.1 per 1000 children in 2011 (Stats SA, 2013). While this has been accompanied by a decrease in the under-five mortality rate (74 deaths per 1000 births in 2000 to 45 deaths per 1000 births in 2012 (World Bank 2013), it is unlikely that the Millennium Development Goal[2] (MDG) target of 20 deaths per 1000 live births will be achieved by 2015.

In South Africa, it is important to understand the drivers of easily preventable diseases as well as the contextual factors that contribute to these outcomes. This will assist in developing contextually relevant interventions for improving the lives of children, in addition to guiding policy related both to water provision as well as child health.

In order to best explore child health outcomes in South Africa, this dissertation focuses on the environmental factors of access to water and water quality as predictors of childhood diarrhoea. The study argues that improving access to piped water alone is not sufficient to ensure

[2] A set of targets adopted by the United Nations in 2000 with the aim of improving the lives of the poor globally. See www.un.org/millenniumgoals/ for more details.

improvements in child health outcomes, but that improved access needs to be accompanied by reliable service delivery, water of a good quality and improved water hygiene practices.

1.2 Rationale

Target C of the 7th MDG is to *halve the portion of people without sustainable access to safe drinking water by 2015* (United Nations, 2008). South Africa is said to be one of the few African countries that has managed to achieve this target (Kebede, Soumbey-Alley, Asamoah-Odei, Lusamba-Dikassa, & Sambo, 2010).While the target speaks to the safety of water, the indicator for this target, *the proportion of the population with sustainable access to an improved water source,* speaks reliability and improved access rather than access to a safe water source. The use of such indicators may superficially indicate that this target has been achieved and therefore the provision of safe water through this indicator is not guaranteed. In addition, this indicator speaks to those populations that access water through improved sources, and not necessarily the ideal water source (piped on site), or even the minimum water supply as set out by the South African Department of Water Affairs and Forestry (DWAF). Monitoring South Africa's progress in meeting the MDG target through such indicators is therefore likely to overestimate the substantive progress made.

As the deadline for the MDGs is fast approaching there is much talk of the post-MDG agenda. This study hopes to provide some guidance in determining future health indicators and objectives. By linking these factors to child health, it is hoped that the analysis, conclusions, and recommendations will assist health and policy planners in determining the best interventions for improving child health outcomes. There will however be a continued need to monitor, and if necessary, adjust projections over time as new health developments and policies are implemented. The intention is that the study will form part of a broader research project which provides a comprehensive and nuanced understanding of the patterns and trends in drinking water provision in South Africa, highlighting the interdependence of access, quality, and reliability of services.

1.3 Overall aim and specific objectives

The overall research aim of the dissertation is twofold. Firstly it aims to investigate access to, and the quality of, municipally provided water in South Africa, as identified by the end users and secondly, to explore the relationship between water access and children's health.

Objectives

1. To improve knowledge and understanding of the dynamics surrounding service delivery, and the supply of water in particular.
2. To review literature on municipally provided water and efforts to improve access and quality.
3. To assess how access to potable water has changed from 2006 to 2011.
4. To investigate the relationship between water access, and particularly inferior water quality, and children's health.
5. To present recommendations based on the findings of the analysis.

1.4 Research questions

The main research question guiding this study was whether the environmental factors of access to water and water quality act as predictors of childhood health? The following sub-questions guided the research:

i. *How did the level of access and quality of municipally provided water change in South Africa between 2006 and 2011?*
ii. *Among the households that had access to the different types of piped water, what was the quality of this water and how did this quality change from 2006 to 2011?*
iii. *Is there a relationship between access to water and the quality of piped water received in a household, and the health of children, as measured by the incidence of diarrhoeal disease?*

1.5 Overview and context of the dissertation

The dissertation is presented in six chapters. Chapter Two (Literature review) provides a review of the current body of literature on the provision of water in South Africa, the current state of water access and water quality in South Africa, and the relationship between water access, water quality and child health. The key themes discussed in the chapter include service delivery, legislation, and regulations pertaining to drinking-water quality and child health measures.

Chapter Three (*Data, definitions and methods)* discusses the nationally representative household survey data analysed in the study, and provides an overview of the key variables and methods used in the research. The chapter includes a discussion of the chosen econometric model and its limitations.

Chapter Four (*Descriptive findings*) explores changes in access to water services and water quality in relation to various water-related variables (such as distance travelled to water source, rating of municipal water service, payment for water, treatment of drinking water and occurrence of water supply interruption) for both 2006 and 2011.

Chapter Five (*Econometric findings and discussion*) presents the sample used in the regression analysis explores the distribution of diarrhoeal disease. The chapter then presents the results of the regression analysis, and provides a discussion in relation to the findings presented in this chapter as well as those presented in Chapter Four.

Chapter Six (*Summary and conclusion*) concludes the dissertation by briefly outlining the research process, the main findings and the policy recommendations.

Chapter 2

2. Literature Review

2.1 Introduction

The relationship between health and environmental conditions is becoming increasingly important given the rise in population levels, particularly within the urban context. Literature points to the notion that access to safe drinking water contributes to more than survival, but has an immense social and economic impact as well. The current state of water access and quality in South Africa can only be fully understood by considering the context from which services originate. This chapter reviews and discusses existing literature related to two of the key objectives of this study. Firstly, it considers water access and quality, exploring the themes of service delivery, and legislation and regulations pertaining to the quality of drinking-water in South Africa. The chapter then discusses the various child health measures and the links between water access, water quality and child health. Finally, a broad framework within which to locate this study is provided.

2.2 Service Delivery in South Africa

South Africa has been through a rapid transition since the advent of democracy in 1994, with significant changes in government, society and within the legislative environment. In order to fully understand the history of water delivery in South Africa, it is important to understand the context and political state of the country. All aspects of life were affected by the apartheid regime, including access to services such as water, sanitation, education, and healthcare. Under the apartheid regime, the Department of Water Affairs was mandated to provide and allocate water. Through the Government's policies, 'independent' homelands that were created for the black majority had to negotiate their access to water. These homelands (or Bantustans), together with their local municipality, were responsible for addressing the service needs of their areas (DWAF, 2004). Water and sanitation services were therefore provided in a fragmented and unreliable manner (Hatting et al., 2007).

Under the Interim Constitution (of 1993) and the permanent South African constitution (Act No. 108 of 1996), all citizens were afforded their basic rights. Included in the Constitution is the Bill of Rights that established a guarantee of fundamental human rights such as the right to access to healthcare, sufficient food and water and social security when applicable (Republic of South Africa, 1996). Policies were consequently put in place that focussed on redressing the injustices of the past. The foundation of these policies was the Reconstruction and Development Programme (RDP), the governments' policy foundation that aimed at meeting the peoples' basic needs through an integrated and sustainable approach (DWAF, 1994). A priority of this programme was the access to basic water supply and sanitation services by all (DWAF, 2004). The Department of Water Affairs and Forestry (DWAF) was established to formally take ownership of the provision of water and sanitation services, mandated by the RDP.

With an estimated 15.2 million people that lacked adequate access to water at the dawn of democracy, of which 12 million were located in rural areas, the task of meeting the objectives of the RDP programme was immense (Muller, 2002). Given that the new government had to build on the existing structures, and that these services needed to be integrated into areas that had already been developed, provided additional challenges (DWAF, 2004; Hatting et al., 2007). The new government embarked on a process of amending the country's philosophy, priorities, and approach to water supply (See section 2.3.1 on Regulatory governance and legislation and regulations relating to drinking-water quality below).

The new South African water legislation has been argued to be world-class, progressive and successful in meeting its objectives to implement policies, strategies and frameworks (De Coning & Sherwill, 2004). However, two decades post-apartheid, there has been an increased concern in the government's ability to fulfil the objectives set out by the new legislation. This is reflected by the rise in service delivery protests noted since 2004, with an increasing number of protests being around water-related issues (Alexander, 2010; Van Vuuren, 2013).

2.3 Provision of water in South Africa

2.3.1 Regulatory governance

Following the era of Apartheid, the new democratic South African government was faced with the mammoth task of building infrastructure, and providing access to basic services to the majority of the population who previously had limited or no access to services. Consequently there have been a number of polices and frameworks developed, with considerable changes seen in the supply of water in South Africa. It has been explicitly stated in the Constitution of South Africa, under section 27 (1) (b), that "everyone has the right to have access to sufficient food and water". This commitment is furthered in section 27 (2), where it is highlighted that "the state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of these rights" (Republic of South Africa, 1996)

In order to fulfil the obligations set out in the Constitution, numerous policies, acts, and strategies were put in place by DWAF. These include:

- White Paper On Water Supply and Sanitation, 1994
  - Emphasises the importance of speedy delivery of basic services
  - Basic water was defined as:
    - A standpipe supplying 25 litres per capita per day;
    - within 200m of the household;
    - at a minimum flow of 10 litres per minute supplied on a regular basis;
    - once minimum quantity is available, water should meet minimum quality standards;
    - should be potable (taste, odour and appearance).
- Water Services Act (WSA) of 1997
  - Aim to support municipalities in their role as water services authorities.
- National Water Act (NWA) of 1998
  - Legislates how water as a resource is to be used, protected, developed, conserved, managed, and controlled.
  - Mandated by Section 24 of the Bill of Rights in the Constitution of South Africa
- Municipal Structures Amendment Act (No 33 of 2000)
  - Decentralized system: shifted the responsibility of water provision onto the local municipalities.
- New White Paper on Water Services, 2002
  - Revision of policies set by 1994 White Paper.
  - Greater emphasis on sustainability and provision of efficient and reliable water services.
  - Local government established as driver of delivery – DWAF to be sector leader.
- Free Basic Services Policy, 2000
  - To provide free basic water and sanitation services
    - Minimum of 3 litres per person per day/ 6 kilolitres per household per month;
    - minimum flow of no less than 10 litres per minute;

  - within 200m of a household; and
  - effectiveness such that interruptions last no more than seven full days a year.

The basic provision of water as set out under the Free Basic Services Policy, was considered to be the minimum requirement and not adequate to ensure a "full, healthy and productive life" (DWA, 2013, p. 9). This minimum forms the base within the water ladder[3], which is followed by an intermediate service level step of access in the yard, and finally the full service level of piped water within the home (DWAF, 2003).

A number of additional strategies and guidelines were established during this period in order to fulfill the abovementioned legislation. These include, but are not limited to:

- Free Basic Water Implementation Guideline for local authorities (2002)
  - Incorporating areas around understanding the needs of the population, establishing institutional frameworks, poverty relief policies, and pricing, amongst others.
- Strategic Framework (2003)
  - Maps a vision for the sector in terms of the provision of water services
  - Specific targets set, which include an end to the bucket system[4] by 2006 and water supply backlog by 2008.
- National Water Resource Strategies (2004, 2012, 2013)
  - Considers issues such as water supply, conservation, and demand management, as well as equity in allocation and monitoring.
- Free Basic Water Implementation Strategy 2007: Consolidating and maintaining
  - Ensuring those households that can afford to pay are doing so, and those that cannot afford to pay are provided adequate free potable water while ensuring the financial viability of the municipality.

[3] A metaphor used by DWAF representing increments in the delivery of water services. This 'ladder' represents movements from basic supply (bottom of the ladder) to the ideal supply of services (top of the ladder).
[4] The use of buckets as sanitation facilities where other forms of sanitation are not available.

The identified legislation and strategies have shaped the Government's programmes targeted at equitable and sustainable water supply and use in South Africa. Further legislation and regulations were also developed relating to the quality of drinking-water.

2.3.2 Legislation and regulations relating to drinking-water quality

The *South African Water Quality Guidelines* set out by DWAF (1996) operate as the principal source of information for determining the water quality requirements for all sectors that utilise water services. Volume 1 sets out the guidelines on domestic water use, providing key information on the fitness of water for human consumption and use. Definitions, ranges, effects, and treatment options based on each of the constituents (properties of water or substances found in water) are provided.

The *Quality of Domestic Water Supplies* (DWAF, 1998) comprises of 5 guides that cover water assessment, sampling guide analysis, treatment and management. These guides explain the general concepts of water quality, suitability of water for domestic use, treatment options, and aspects relating to the management of water.

The South African National Standard (SANS) *241 Drinking Water Specification* (SANS, 2011) provides the guide levels for the various parameters of drinking water quality in South Africa. These include constituents to be tests, intervals of testing and class limits. SANS 241 Drinking-Water Specifications are based on the WHO limits, and provide two classifications of water that indicate the acceptable standard of drinking water: Class I: Acceptable for lifetime consumption; Class II: Maximum Allowable.

Key constituents for compliance monitoring include:

- Microbiological indicator organisms (E. coli);
- Physical and organoleptic requirements (such as colour, conductivity, odour, taste, aesthetic);
- Concentrations of chemicals used in treatment processes;
- Any health-related constituent that exceeds the guideline value;
- Any other potential constituents of concern identified.

Under the Water Services Act (No. 108 of 1997), drinking water quality failure occurs when SANS 241 Drinking Water Specification water fails both SANS 241 class limits (DWAF, 2005).

2.3.3 Access to water

Access to potable water (safe drinking water) has been a priority of the government, which set itself the target of universal access to potable water and basic sanitation by 2014 (Stats SA, 2011a). Between 1994 and 2002, new water services had been instituted, and this was one of the largest and fastest development programs in Africa (Muller, 2002). By 2010, access to potable water had reached 92.9%, a remarkable increase from the 1994 level of 59% (Stats SA, 2011a). While there has been a notable overall progress, ease of access to potable water remains low in some provinces. In 2010, for example, a mere 13.6% of households in Limpopo were estimated to have access to municipal water in their dwellings. While the overall improvements have been substantial, roughly 1.65 million people still do not have access to the municipal water supply, and nearly 2 million access water services at a sub-minimum level (National Treasury, 2011).

The Millennium Development Goals (MDG’s), a set of targets adopted by the United Nations in 2000 with the aim of improving the lives of the poor globally, focuses on halving the proportion of people without access to safe drinking water by 2015 (Stats SA, 2013). As considered here, the focus lies in improving access to water, while the safety of water, as determined by its quality, is considered a secondary objective. Interruptions to water supply, long distances travelled and poor ratings of the quality of services provided all form critical components of the realisation of the MDG’s and other development-orientated goals which have been set.

2.3.4 Quality of water

Water quality is considered one of the key indicators of health and well-being. With numerous studies linking drinking water to a vast number of microbial infections, the primary aim of water quality management should be to ensure that end users are not exposed to doses of disease causing pathogens (Grabow, Taylor, Clay, & de Villiers, 2000). The importance of access to water of a good quality has been highlighted by the United Nations Committee on Economic, Cultural and Social Rights (UNCESCR) where “the human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses.” (UNCESCR, 2002, p. 2)

In 2004, the DWAF undertook a Strategic Survey on Drinking-Water Quality in South Africa, in order to assess compliance by local authorities to drinking water standards. Only 43% of municipalities were found to have adhered to the legislated water quality requirements. Furthermore, the results indicated that Water Service Authorities were not familiar with the drinking water standards, and a lack of monitoring of water quality resulted in the provision of services that did not meet the legislated levels of service (DWAF, 2005). As a result, the Blue Drop regulation programme was initiated as a catalyst for improved water quality management nationally (DWA, 2010). The Blue Drop certification encompasses chemical and physical compliance with the SANS 241: Specifications for Drinking Water (SANS, 2011). In 2009, less than 50% of municipalities monitored their water quality. By 2010, 45% of municipalities were found to be in need of attention or in need of urgent attention relating to their water quality levels. Provincial Blue Drop scores ranged from 46.87% in the Northern Cape to 92.45% in the Western Cape (DWA, 2010).

The municipalities' management of water quality forms one area of management. Contamination of water can occur at different stages, starting with inadequately treated water entering the distribution system, to faults within the distribution system and lastly post-delivery contamination. Microbiological quality of water decreases with transport and storage, and therefore the likelihood of contamination increases substantially between source and final use in the household. Consequently, households without piped water in their dwellings run an increased risk of contamination (WHO, 1997; Wright, Gundry, & Conroy, 2004). This highlights the importance of efficient management of water quality at various levels.

2.4 Child health

Childhood development is the most important developmental phase of an individual's life, and is the foundation on which later development occurs (Grantham-McGregor et al., 2007). Development during the initial years of life affects physical and mental health and behaviour throughout one's lifetime (Grantham-McGregor et al., 2007; Mustard, 2010; Waters, Goldfield, & Hopkins, 2007). Investments during the pre-natal and childhood years are therefore of paramount importance for the development of children into healthy adults, particularly for those living in disadvantaged communities (Waters et al., 2007). Poor development is likely to have many effects including under-achievement in school, which in turn affects wage earning potential, as well as the transfer of deprivation to future generations thereby furthering the intergenerational transmission of poverty (WHO, 2009).

It is evident that development during the formative years is important, and children bear the burden of many preventable diseases (Smith, Corvalán, & Kjellström, 1999). In view of this, studies that seek to uncover the health impact of service provision often focus on children under the age of five years as their target sample.

2.4.1 Diarrhoeal disease

Diarrhoeal disease is a leading cause of mortality and morbidity amongst children under 5 years (Robert E. Black et al., 2010; UNICEF, 2009). Environmental conditions are said to have a significant impact on diarrhoeal disease, with 88% of global diarrhoeal deaths being attributed to unsafe drinking water, poor sanitation facilities, and inferior hygiene practices (R. E. Black, Morris, & Bryce, 2003; WHO, 1999; Woldemicael, 2001). The incidence of diarrhoeal disease among children is often used when investigating various health, nutritional, and environmental issues in less developed countries. Assis, Barreto, Santos, Fiaccone, and da Silva Gomes (2005) for example, assessed the impact of childhood diarrhoea on the growth patterns of preschool children in Brazil. The study found that the incidence of diarrhoea is a key determinant of poor growth as observed by weights-for-age Z-scores. Niehaus et al. (2002) assessed the long-term impact of childhood diarrhoeal disease on the cognitive functions of children through non-verbal intelligence, short-term visual memory and short-term memory, attention and concentration tests. Accounting for the impacts of maternal education, duration of breast-feeding, and childhood worms (helminthiasis), this study found that all three of these tests, (non-verbal intelligence, short-term visual memory and short-term memory, attention and concentration tests) were inversely correlated with both early childhood diarrhoea and nutritional status, as well as both being independently correlated with impaired cognitive function, hence the impact is in fact two-fold (Niehaus et al., 2002).

2.4.2 Nutrition

The Constitution of South Africa, section 28(1) (c paragraph 76), refers to 'basic nutrition' as a basic right. This assumes access to sufficient water of a minimum quality so as to allow for 'drinking, food preparation, and even food production'. Nutrition and health are closely related throughout an individual's life; however, this link is particularly important during childhood, given the level of development that occurs during these early years. With a large number of the most prevalent diseases occurring during the formative childhood years, good nutrition is one of the key defences to many childhood illnesses. Evidence suggests that diarrhoea (both acute and persistent), which this study focuses on, is a significant cause of malnutrition and can further exacerbate existing malnutrition (Vanderkooi, 2000). The converse is also true, chronic malnutrition may make a person more susceptible to diarrhoea (Ergin, Okyay, Atasoylu, & Beser, 2007; Fratamico, Smith, & Brogden, 2009). In a report by the World Bank, it was concluded that child under-nutrition occurs through recurring infections caused by poor environmental factors rather than food security (Shekar, Heaver, & Lee, 2006).

2.4.3 Environmental factors

Environmental aspects such as housing location can influence child health outcomes. Children under the age of five years form a tenth of the world's population, however, 40% of the world-wide burden of disease attributable to environmental conditions occurs in this population (WHO, 2007). Children growing up in over-crowed areas with lower levels of access to basic services such as cooking, water, sanitation and healthcare facilities; were found to experience greater levels of illness compared to those living in better environmental conditions (Cummins & Jackson, 2001; Fink, Günther, & Hill, 2014; World Bank, 2008). People living in these conditions often lack access to services such as home affairs resulting in children being unregistered, further limiting their access to services (Fink et al., 2014; Lansley, 2014).

2.4.4 Other factors

Person level factors of age and gender may influence the health status of a child. Males are often favoured in terms of the allocation of resources in households, including food and healthcare (Khera, Jain, Lodha, & Ramakrishnan, 2014). The gender of the household head has also been found to impact health outcomes among children. Headship affects the access and allocation of resources that contribute to child health (UNICEF, 2011). In their report, UNICEF (2011) note that while some studies find a positive association between female headship and a higher level of spending on health and nutrition of the family, others find that children of female-headed households are disadvantaged given the relatively lower levels of income accrued by female headed households, compared to their male counterparts. The impact of headship is therefore highly contextual (UNICEF, 2011). The age of a child is also likely to be related to their health outcomes, both in terms of the biological risk factors (Mott, Fore, Curtis, & Solomon, 1997) as well as the intra-household allocation of resources (Paul, Doocy, Tappis, & Funna Evelyn, 2014; Sauerborn, Berman, & Nougtara, 1996) Household size has also been found to affect the intra-household allocation of resources, with larger households being associated with food insecurity, given that more people have to eat from the same food supply (Baer & Madrigal, 1993; Ihabi et al., 2013).

The impact of the age of the household head on child outcomes may be associated with a number of other characteristics such as education level and gender. When controlling for these other characteristics, older household heads are correlated with better child health outcomes, which is usually related to their ability to access assets, in particular, food security (Arene & Anyaeji, 2010; Kimani-Murage et al., 2011).

Many studies have also found socio-economic status, mothers' education, access to toilet facilities, and access to healthcare amongst others to be significant predictors of childhood health (El-Gilany & Hammad, 2005; Molbak, Jensen, Ingholt, & Aaby, 1997; Mondal, Hossain, & Ali, 2009). When assessing the impact of income, these studies found that households with higher income experience reduced incidences of diarrhoeal disease (Boadi & Kuitunen, 2005; Bozkurt, Ozgur, & Ozcirpici, 2003). The relationship between income and child health reflects the household's choice. Households with higher incomes are able to choose to live in areas with greater service access. Providing access to services alone will not ensure improved health. Bank, Minkley, and Kamman (2010) argue that even where services exist, income (the lack thereof) results in financial barriers to access.

Literature has revealed that enhancements to overall child health through improving nutritional intake or decreasing the prevalence of diseases can result in improved educational outcomes, labour supply and the long-term economic status of individuals (Bobonis, Miguel, & Puri-Sharma, 2006; Miguel & Kremer, 2004). Developing resilient children, increasing defensive factors and decreasing risk factors are likely to have substantial advantageous effects on the future of children (Waters et al., 2007). A key factor that has been found to influence health and nutritional outcomes of children is access to clean water (Charmarbagwala, Ranger, Waddington, & White, 2004; UNFPA & IPEA, 2007).

2.5 Water access and quality and its link to child health: a focus on diarrhoea

2.5.1 The international context

Numerous international studies have used the incidence of diarrhoeal disease to assess the quality of potable water. The United States of America's Centres for Disease Control and Prevention (CDC,1998) () (72) undertook a survey in Jamaica to assess the consistency of water provision and customer satisfaction with regards to water services and water quality, in relation to incidence of gastrointestinal illnesses experienced within the community. This study found that residual chlorine levels decrease through handling and storage of water, with storage in a secondary unit leading to increased opportunity for contamination. The CDC highlighted the need to improve access and proximity to piped water, as well as reducing the incidence of interruptions in such a community, all of which will help decrease the use of stored water, thereby reducing the risk of consumption of water of inferior quality. More generally, a systematic review looking at self-reported diarrhoeal disease and distance of home to source indicates that distance to water source is an important risk factor for diarrhoeal disease in children (Wang & Hunter, 2010).

The *Manual on Environmental Health Indicators and Benchmarks* suggests that in many developing countries, infant morbidity and mortality rates relating to diarrhoeal disease can be used as key indicators of the impact of unsafe drinking water (Ahmed, Ferring, & Ruiz, 2005; Levy, 2007). A systematic review of empirical studies linking poor microbial water quality with all-age incidence of diarrhoeal disease and under-five incidence of diarrhoeal disease echoes these findings (Thomas Clasen, Schmidt, Rabie, Roberts, & Cairncross, 2007).

Understanding how water access and water quality independently affect child health is important for the design of appropriate interventions. Literature often focuses on the overall health impact of water, rather than delineating by access and quality, and in many cases water and sanitation effects are combined, making it difficult to isolate disease transmission routes accurately. Studies often combine the impacts of both water and sanitation given that water and sanitation are highly correlated. Having access to a flush toilet by definition implies access to piped water of some sort, whether on or off site.

Some studies suggest that increasing access to water is more important than increasing quality, as improvements in access allow for improved hygienic practices, which in turn would reduce the transmission of diseases (Curtis, Cairncross, & Yonli, 2000; Esrey, 1996). However, evidence from other randomized studies indicates that increasing access to water without changing quality does not reduce the incidence of diarrhoeal disease, suggesting that the gains from improved access are influenced by other factors within a particular context (Kremer, Ahuja, & Zwane, 2010). Improvements in access have considerable private benefits in addition to potentially reducing the chances of contamination, though such improvements do not automatically improve the quality of water consumed (Devoto, Duflo, Dupas, Pariente, & Pons, 2011). A systematic review of 30 interventions to improve water quality in the prevention of diarrhoeal disease indicated that end-use interventions are more effective in preventing diarrhoea when compared to interventions at the water source. Effectiveness was influenced by compliance rather than programmes combining home-based interventions with other environmental approaches, such as improved water supply and sanitation services, improvements in water storage or hygiene promotion (T Clasen, Roberts, Rabie, Schmidt, & Cairncross, 2009).

Studies indicate that educating households about water quality leads to increased levels of water treatment which is known to reduce communicable diseases such as diarrhoeal disease. (Anderson, Phillips, Wentzel, & Romani, 2010; Luoto, Levine, & Albert, 2011). In a review of randomized evaluations of access and quality of water in developing countries, households that treat their drinking water were found to reduce diarrhoea by 20 to 40% (Kremer et al., 2010). Fuentes, Pfütze, and Seck (2006) found that access to clean water and improvements in mothers' education are the key interventions to reducing childhood illness. In addition, the health benefits of reducing the incidence of illness can be significantly greater in households that have access to the ideal infrastructure (piped water and flush toilets). Some studies identify that household size and the use of pit latrine sanitation systems have more significant associations with diarrhoeal disease than water quality (Centres for Disease Control and Prevention, 2008; Mahendraker, Dutta, Urmil, & Moorthy, 1991). However, it was noted that pit latrines are most common in households without access to municipally provided water; hence hygiene standards could be lower in these cases (Centres for Disease Control and Prevention, 2008).

2.5.2 The South African context

Within the South African context, diarrhoeal disease was found to be associated with poor water quality (Bessong, Odiyo, Musekene, & Tessema, 2009; C. L. Obi, Potgieter, Bessong, & Matsaung, 2003). Lewin et al. (2007) estimated the burden of disease attributable to unsafe water, sanitation and hygiene in the under-five cohort, to comprise 9.3% of child mortality and 7.4% of child morbidity. Similar findings were noted in the Western Cape *Burden of Disease* project in that inadequate water supply was found to be a significant determinant of diarrhoea-specific infant mortality (Sanders et al., 2007).

In South Africa, the burden of HIV/AIDS poses additional challenges to health outcomes, given that HIV positive persons are more susceptible to diarrhoeal and other common diseases as a result of the compromised immune system that is associated with HIV/AIDS (Abong'o & Momba, 2008; C. Obi et al., 2006).

Using the South African Demographic Health survey data, Choi (2003) sought to determine the predictors of childhood diarrhoea. While access to piped water was found to be a significant predictor of childhood diarrhoeal disease in initial models, when accounting for other possible correlates, this variable was found not to be a significant predictor of the disease. Race, the age of the child and living in the provinces of KwaZulu-Natal and Mpumalanga were found to significantly predict child diarrhoea in the full model. In a study conducted by von Schirnding, Yach, Blignault, and Mathews (1991), lack of on-site access to water was found to be a risk factor for childhood diarrhoeal disease. Other correlates included the availability of sanitation and electricity facilities, refuse removal, over-crowding and low socio-economic status.

Household treatment of water, source water quality, water storage containers and the bacteria associated with the storage container were also found to be significant correlates of childhood diarrhoea (Mellor, Smith, Learmonth, Netshandama, & Dillingham, 2012). Modelling of the long term behavioural relationships indicates that simultaneous interventions related to these factors can be effective in reducing diarrhoeal rates (Mellor et al., 2012). Majuru, Michael Mokoena, Jagals, and Hunter (2011) followed three communities, two of which were to have improved water supplies installed during the course of the study. After having received the improvements to their water systems, the two communities in which interventions had taken place reported a 57% decrease in diarrhoea. The new systems were however operationally unreliable. The community experiencing the more reliable delivery was found to be associated with lower levels of illness compared to the community experiencing the less reliable system. The findings of this study suggest that the benefits of improved systems are diminished if such systems do not operate in a reliable manner. This highlights the importance of reliable service delivery in determining health outcomes.

Genthe, Strauss, Vundule, Maforah, and Seager (1995) conducted a study on the correlates of diarrhoeal disease in poor communities. They found that access to clean water has a protective effect on child health. Incidence of diarrhoeal disease was greater for households that obtained water from communal sites compared to those that have on-site access. This study found knowledge of food handling, hygiene and attendance at child care centres to be better predictors of child health than the provision of potable water alone. In addition, they found that access to sanitation had a smaller impact on incidence of diarrhoeal disease compared to access to water supply. Balfour (2006) argues that in South Africa, the increased levels of water access has meant that access to sanitation, hygiene education and water quality will increasingly play a greater role in preventing diarrhoeal and other water-related diseases.

2.6 Theoretical perspectives on water access and quality

Based on the literature presented above, the conceptual framework set out by Mosley and Chen (1984) provides some underpinning to this study. This model was created as a framework to better understand child mortality in developing countries. The model is based on the premise that social and economic determinants act through proximate determinants to affect child mortality. These determinants occur at the individual, household and community levels. This model speaks to the immediate causes of poor health such as poor access to food and healthcare services, and underlying factors such as family income. Schultz (1984) speaks of this in terms of a health production function where child mortality is dependent on observed and unobserved health factors. The unobserved factors represent those factors that influence child health but are seldom captured such as individual preferences and biological attributes. While this study does not cover all the proximate factors present in Mosely and Chen's framework, it draws on aspects of this model so as to derive a model that is grounded in theory.

2.7 Conclusion

In this chapter, context-related and empirical literature which informs this study was reviewed. The chapter first considered the South African context of water access and quality, exploring the transition of service delivery that progressed to a more equitable allocation of resources. A review of South African legislation and regulations pertaining to drinking-water access and quality then followed. It was noted that despite these developments, a lack of monitoring and control in relation to water quality legislation has led to sub-optimal levels of quality being provided.

The chapter then reviewed the various child health measures, focusing on one of the most prevalent childhood diseases, diarrhoea. Studies linking diarrhoeal disease to both water access and quality both internationally and locally indicate the role these factors play in determining child health outcomes. A review of the literature assisted in isolating correlates of child health for inclusion as control variables in the analysis part of this study.

Chapter Three

3. Data, Definitions and Methods

3.1 Introduction

To reiterate, the aim of this study is two-fold. This study firstly aims to track changes in water related variables between 2006 and 2011. To achieve this, data from the 2006 and 2011 General Household Surveys (GHSs) was analysed. The second part of this study aims to assess the relationship between water access, water quality and child health. To achieve this, the study focuses on data from the 2011 GHS and in particular looks at the diarrhoeal disease as the health outcome variable in relation to key independent variables. Drawing from the empirical studies reviewed in Chapter Two, this chapter describes the data, defines the key variables, and sets out the methods used in this study.

3.2 Data Sources

This study analysed data from the 2006 and 2011 GHSs (Stats SA, 2006, 2011). The GHS is a nationally representative household survey that is conducted annually by Statistics South Africa (Stats SA) and contains data on approximately 30 000 households in the country. The GHS is a cross-sectional survey of private households where information is obtained from numerous individuals/households at one point in time. The survey does not include collective living quarters such as student residences, old age homes, prisons, hospitals, and military barracks. The survey is therefore only nationally representative of all non-institutionalised and non-military based persons in South Africa. Weighted data are used in the analysis such that the results are representative for the whole population. Specifically, Stats SA weights that have been derived from the 2008 midyear population estimates are used (Stats SA, 2011b).

The language mode of the GHS is English. Enumerators specialising in the 11 official languages are trained and given the questionnaires to translate and administer with specific instructions. This is an unconventional method as the information acquired is subject to two levels of error, namely the enumerator not translating the question correctly and the enumerator not understanding or recording the response correctly. This can result in respondent bias and interviewer effect. However, due to the large number of official languages in South Africa, and the practical difficulties of enumerators carrying questionnaires in all the languages, this method has been used to streamline the process.

3.3 Definitions and the associated limitations

Water access refers to the household's main source of drinking water (see question 3.12 in the GHS 2011 and question 4.19 in the GHS 2006 in Appendix 1). If multiple sources are used, the GHS asks respondents to indicate the source that is used for drinking/cooking. The objective of this question is to ascertain whether the majority of households receive water inside their dwelling, on site or at a communal point.

In the subsequent analysis, the water source is restricted to that provided by the municipality. This restriction is made as the study aims to assess the quality of service delivery whilst looking at issues of access and quality. The wording of this question has changed from 2006 to 2011. The GHS 2006 asks if the household has access to piped municipally provided water; whereas the GHS 2011 asks if the household's main source of drinking water is supplied by a municipality (see question 3.16 in the GHS 2011 and question 4.23 in the GHS 2006). The 2006 survey is likely to both underestimate and overestimate the proportion of households that have municipally provided water, for different reasons. On the one hand, due to the wording of the question, households may have access to piped municipally provided water, but this may not be the main source of their drinking water, leading to an overestimate compared to the 2011 measure. On the other hand, the question restricts access to municipal water to that which is piped only, which can lead to an underestimation of results as households that have access to other sources of municipally provided water (such as borehole on/off site, communal tap and water carrier/tank) are excluded. As a result, this study limited its analysis to water which is piped and the main source being that provided by the municipality, in order to assess changes between 2006 and 2011. Comparisons between the relevant questions asked in the GHS 2006 and 2011 can be made by referring to Appendix 1.

Where applicable, the distance to water sources will be analysed as well. Five answer categories are available: less than 200 meters, 201-500 meters, 501 meters-1 kilometre, more than 1 kilometre and Do not know (see question 3.13a in the GHS 2011 and 4.20 in the GHS 2006). This was done in order to ascertain how far households with the lowest form of piped water access travel to obtain their drinking water. This variable is considered in relation to the basic water supply guidelines as well as to determine the potential influence that water contamination through transporting drinking water has. When surveying this question, the enumerator states that 200m is the equivalent length of two soccer fields (Stats SA 2006; 2011). The results of this question may therefore be biased as it relies on the judgement of the respondent in terms of distance.

The next step was to look at the quality of municipally provided water. In this study water quality was measured by the assessments of consumers, concerning the nature of the water provided and the quality of the service provided. Where reference is made to water quality in this study, this refers to households perceptions of the quality of their water.

This was assessed in terms of turbidity, smell; taste and being safe to drink (see question 3.14 in the GHS 2011 and question 4.21 in the GHS 2006). The quality of the service delivery was assessed in terms of the need to treat water again (see question 3.15 in the GHS 2011 and 4.22 in the GHS 2006), household rating of the municipal water services they receive either as good, average or poor (see question 3.17 in the GHS 2011 and question 4.24 in the GHS 2006), and the occurrence of interruptions (see questions 3.19 in the GHS 2011 and 4.27 in the GHS 2006). The occurrence of interruptions in the GHS 2011 is classified as whether or not the household has experienced an interruption in the past 12 months. To make results comparable, the GHS 2006 response categories to daily, weekly, monthly, 6-monthly and yearly was re-categorized as *interruptions more than once a year*.

Payment for water was assessed to determine if there is an association between the quality of water received and payment (see question 3.18 in the GHS 2011 and question 4.25 in the GHS 2006).

3.3.1 Sample parameters

The second part of the empirical aspect of this study investigates the implications of water access and water quality on child health. The reviewed literature in Chapter Two suggests the burden of diarrhoeal disease falls disproportionately on the young as viral pathogens predominate in infants and young children (Smith et al., 1999). The sample for the regression analysis was therefore limited to children under the age of 5 years. The state of the burden of diarrhoeal disease in South Africa in 2011 is presented as part of this section, and the household and water-related links are briefly explored.

3.4 Dependent variable: Child health

Child health was measured by the incidence of diarrhoea among children (younger than five years of age) in the month preceding the surveying of households in the GHS (See question 1.26 in the GHS 2011). The information collected in the GHS is self-reported incidences of diarrhoea.

3.5 Independent variables

The key objective of this study is to assess if water access and water quality predicts child health. In order to isolate whether these factors had an independent effect on child health the study controlled for a range of individual and household characteristics that were likely to affect child health.

3.5.1 Key explanatory Variables

The key independent variables relating to water as a household characteristic were:

- Access to on-site piped municipal water (Yes/No);
- Water quality (Safe to drink –Yes/No, turbidity: Clear – Yes/No, good in taste – Yes/No and free from bad smell –Yes/No);
- Distance to water source (less than 200 meters, 201-500 meters, 501meters-1 kilometre, more than 1 kilometre and Do not know); and
- Need to treat water again (Yes, always; Yes, sometimes; No, never).

The different quality variables as listed above, were explored in the descriptive analysis, however given that they were found to be highly correlated, as expected; they were all analysed bivariately but only one variable was used in the regression analysis. Similarly, distance to water source was explored in the descriptive analysis but was found to not add to the predictive power of the model and was therefore excluded from the regression analysis.

3.5.2 Independent variables

3.5.2.1 Maternal and child-specific characteristics

Numerous maternal characteristics were included in this study. Due to the nature of families in South Africa and how the GHS captures data on the household roster, matching a child to its biological mother proved difficult. A proxy variable for mothers' education based on the highest educational level achieved by female adults in the family was therefore used (see question 1.6 in the GHS 2011). This variable is based on four education level cohorts: those adult females in the household with no schooling, those with 7 years of education and less, those with between 7 and 12 years of education and those with more than 12 years of education. The proxy variable for maternal education was analysed and found not to contribute to the model and was subsequently excluded from the final model.

Child nutrition was assessed by considering the number of children that went hungry “often” or “always” (see question 3.52 in the GHS 2011). The GHS asks: “in the last 12 months did any child in the household go hungry because there wasn’t enough food” where child is defined as those individuals 17 years and younger. Since the sample in this study has been restricted to those children under the age of five years, it is not possible to distinguish the proportion of children under the age of five that have gone hungry. It is noted that assuming if one child in a household went hungry, all children in the household went hungry is not an accurate reflection of the state of hunger in this cohort and will form a limitation to the study. The use of this variable in this instance aims to assess the nutritional status of children in general rather than which cohort of children in particular have gone hungry in the past. As noted in Chapter Two, hunger and under-nutrition are not the same. Under-nutrition is caused by low intake or absorption of food hence in this study it is assumed that children who go hungry “often” or “always” do not consume sufficient food to provide adequate nutrition (FAO, WFP, & IFAD, 2012). Given the assumptions made for this variable, it was not unexpected that the variable was found not to contribute to the explanatory power of the model and was therefore excluded from the final model.

Other related variables that were included in this study in order to reduce biases in the regression analysis include the following:

- Child’s sex (male, female),
- Child’s age, and
- Race (Black/African, Coloured, Indian/Asian, White, Other),

3.5.2.2 Household-level characteristics

Household income is said to be an important predictor of child health (Boadi & Kuitunen, 2005; Bozkurt et al., 2003). The impact of income is multi-fold, relating to all aspects of a child’s life and the health of a child. Household food security is closely related to the access to food of adequate nutrition at the level of the household level. Household food security is largely influenced by income and asset level (FAO et al., 2012). Furthermore households of higher income are more likely to be in areas of improved access to services including healthcare services. It is therefore important to include income as a control variable to insure that specification bias does not occur. The GHS does not capture the receipt of all sources of income. The total household expenditure was therefore be used as a proxy for income. This is a common practice as expenditure mostly reflects permanent income of households whereas income data generally suffers from measurement error and may include temporary income (Ahmad, Safdar, & Sher, 2012; Burney & Khan, 1991)

Household expenditure cannot accurately reflect resource allocation as it does not account for the size of the household. Therefore, including household size does not only provide a more accurate understanding of the linkage between income and child health but some authors also found that household size has a greater association with diarrhoeal disease than water quality (Centres for Disease Control and Prevention, 2008; Mahendraker et al., 1991). Household size was categorised as the number of adults and children who have spent on average four nights a week over the past four weeks in the same dwelling unit number.

Empirical literature asserts the significance of the correlation between access to toilet facilities and incidence of childhood diarrhoea (Fink, Günther *et al*. 2014). Consequently, this variable forms a crucial factor in regression analysis to ensure specification bias does not occur. The issue arises in that access to toilet facilities is highly correlated with access to piped water and this is likely to result in partial collinearity in the model. Remedies to collinearity include rethinking the model (Gujarati, 2003).In this instance, one regression was run with amongst other variables, access to piped water but access to toilet facilities was omitted. An additional regression was run with amongst other variables, access to toilet facilities where access to piped water was omitted. Access to toilet facilities was used as two binary variables comprising of access to flush toilet or access to chemical toilet (see question 3.22 in the GHS).

Access to healthcare facilities is likely to impact on incidence levels, however questions pertaining to access to healthcare in the GHSs do not allow for easy analysis of access. As a result this variable is not included in this study and will form a limitation to the study.

Other related variables that were included in this study in order to reduce biases in the regression analysis include the following:

- Province of residence;
- Geographic type (Urban formal, urban informal, rural, tribal/traditional)

3.6 Methods

The data have been analysed in two ways. The first section comprises descriptive analysis of data from 2006 and 2011. Chapter Four provides an overview of the data including the characteristics of households, mapping access to piped water by province, distances travelled to water source for those households without on-site access, ratings and payment for water, treatment of drinking water and interruptions to water supply.

The second part of the empirical study involved developing an econometric model and running a set of regressions which estimates the predictors of child health (incidences of diarrhoeal disease in children under the age of five years) as the dependent variable. A number of control variables were included in this analysis and will be discussed as well in the next chapter.

3.7 Choice of econometric model

This study uses a probit model.

The outcome of the variable of interest has two possible states:

$Y=1$ if child experienced an episode of diarrhoea in the month prior to the survey

$Y=0$ otherwise.

The probability of each event occurring is given by

$$\text{Prob}(Y=1) = F(\beta' x)$$

$$\text{Prob}(Y=0) = 1 - F(\beta' x)$$

The probability of choosing any alternative or not choosing it can be expressed as follows

$$P = F(\beta' X) = \int_{-\infty}^{\beta' X} \frac{1}{\sqrt{2\pi}} e^{\frac{-t^2}{2}} dt$$

$$= \Phi\ (\beta \mathbf{x}_i)$$

This represents the cumulative distribution of a standard normal variable.

Although not directly interpretable, the parameters of a probit regression can be interpreted as the change in probability associated with a unit change in the independent variable. The regression coefficients indicate the change in the z-score for a unit change in the predictor. This relationship can be interpreted as the marginal effect. The marginal effect accounts for the partial change in the probability.

$$\frac{\partial P}{\partial x_j} = \Phi\,(x_i'\beta)\beta_j$$

Where Φ is the probability density function of a standard normal variable.

The marginal effect provides insight into how the explanatory variables alter the probability of incidence of diarrhoea.

3.8 **Conclusion**

This chapter explored the data used in this study whilst identifying and explaining the key variables used as well as their limitations. Key differences in the GHS 2006 questionnaire and GHS 2011 were highlighted with details pertaining to newly created variables explained. The first set of methods encompasses descriptive statistics to determine changes in water access and quality between 2006 and 2011. Bivariate analysis is then used establish a base for the relationship between water quality and child health. The second set of methods encompasses an econometric analysis which estimates the predictors of child health. The economic model utilised was discussed. This chapter laid the foundation for the data analysis and the creation of the regression model which is discussed extensively in Chapter Five.

Chapter Four

4. Descriptive Analysis: - Demographic and Water-Specific Characteristics

4.1 Introduction

This chapter provides a detailed summary of the various water related variables included in this study. A brief description of the number and location of the households sampled in the surveys used is provided, with a particular focus on the access that households have to water, and the quality of the water service and supply. This process will aid in uncovering the changes that have occurred between 2006 and 2011.

4.2 Demographic characteristics of households

The characteristics of the weighted households included in the survey are summarized in table 4.1 (overleaf). A total of 27 999 and 25 086 households were surveyed in the 2006 and 2011 waves of the GHS respectively. Using weights as provided by Stats SA, these data represent the population of South Africa at large. In 2011, the majority of households were found in urban formal areas, followed by tribal/traditional areas. Households were primarily found in non-metropolitan areas. Data on these computed variables are not available for 2006.

The mean household size did not change substantially since 2006 and remained at just over three people. The range in household size has increased slightly to 25 in 2011. Black African households comprised the majority of households, followed by Whites, Coloureds, and Indians. This distribution remains the same for both waves of this survey. The distribution of households across the nine provinces of South Africa remains largely constant since 2006. In 2006, KwaZulu-Natal was the most populous province followed by Gauteng and the Eastern Cape. In 2011, the population of Gauteng was the largest.

Table 4-1: Characteristics of households, 2006 and 2011

		Unit	2006	2011
Household characteristics	Mean household size	People	3.22	3.30
	Standard error	S.E	2.30	2.42
	Range of households size	People	22	25
Race groups	African	%	78.93	79.60
	Indian	%	2.55	2.63
	White	%	9.54	8.77
	Coloured	%	8.98	9.00
Provincial distribution	Western Cape	%	10.62	11.06
	Eastern Cape	%	13.8	13.23
	Northern Cape	%	2.35	2.3
	Free State	%	5.95	5.83
	KwaZulu-Natal	%	21.23	21.13
	North West	%	7.03	6.96
	Gauteng	%	20.87	21.76
	Mpumalanga	%	7.37	7.28
	Limpopo	%	10.77	10.46

Source: Own calculations using weighted GHS 2006 and 2011 data (Stats SA 2006; 2011)

4.3 Water specific characteristics

The GHSs collected information on water specific characteristics in a number of household-level questions. This section will first discuss the following characteristics: 1) access to piped drinking water, 2) the distance travelled to the source of piped water (where applicable), 3) municipal water which documents payment for water, rating of water and quality of water, and 4) interruptions to water supply.

4.4 Access to piped water

Access to piped water is assessed by province and data were delineated by the four forms of access - namely in the dwelling, on site, use of a neighbour's tap and use of a communal standpipe. Tables 4.2 and 4.4 indicate the percentages of households who have access to piped water by province for 2006 followed by 2011. Having access to water does not necessarily mean that this access is easily attainable. Tables 4.3 and 4.5 provide distances travelled by those households who utilise offsite water supplies for the two respective years.

In 2006 some 12 million households had access to municipally provided piped water. This equates to 88.6% of all households in the country. Of these households which had access to piped water, 71.1% had access in either their homes or their yards. Overall, few households utilised piped water from neighbours' taps (2.0%) while 15.4% of all households reported using communal standpipes as their main source of drinking water.

Table 4-2: Access to piped drinking water, by province 2006

	Piped in the dwelling		Piped in the yard		Neighbour's tap		Communal tap		Total piped	
	N	%	N	%	N	%	N	%	N	%
Western Cape	984115	73.84	262541	19.70	7305	0.55	70492	5.29	1324453	99.37
Eastern Cape	472157	29.26	270186	16.74	20219	1.25	378429	23.45	1140991	70.70
Northern Cape	131024	46.07	92043	32.37	2306	0.81	46060	16.20	271433	95.45
Free State	293728	37.26	412713	52.36	12089	1.53	49847	6.32	768377	97.48
KwaZulu-Natal	856648	36.37	593504	25.20	52439	2.23	420331	17.85	1922922	81.64
North West	250965	28.65	342274	39.07	28337	3.23	174625	19.93	796201	90.88
Gauteng	1691072	54.00	1101391	35.17	40612	1.30	233612	7.46	3066687	97.92
Mpumalanga	250054	28.50	331803	37.82	39414	4.49	158223	18.03	779494	88.85
Limpopo	192057	15.79	342928	28.20	53259	4.38	395741	32.54	983985	80.90
Total	5121820	41.05	3749383	30.05	255980	2.05	1927360	15.45	11054543	88.60

Source: Own calculations using weighted GHS 2006 data (Stats SA, 2006)

When assessing access by province, it is evident that some provinces have achieved exceptional outcomes with regard to overall piped access. This is particularly evident in the Western Cape where 99.4% of households had access to some form of piped water. Other provinces which exhibit high rates of access include Gauteng (97.9%), Free State (97.5%), and the Northern Cape (95.4 %). The Eastern Cape appears to be the only province which falls behind in terms of overall piped water access at 70.7% of households. However, only 29.3% had access in their homes. Similarly, Limpopo province achieved a fairly high rate of piped access (80.9%); this province had connected only 15.8% of households to piped access in the dwelling. Overall, only a sixth of all households accessed piped water through communal stand pipes, this percent was considerably larger in certain provinces individually (Eastern Cape = 23.4%, Limpopo = 32.5%).

Table 4-3: Access to piped drinking water, by province 2011

	Piped in the dwelling		Piped in the yard		Neighbour's tap		Communal tap		Total Piped	
	N	%	N	%	N	%	N	%	N	%
Western Cape	1249453	79.02	202583	12.81	12070	0.76	109399	6.92	1573505	99.52
Eastern Cape	557533	30.64	240784	13.23	28056	1.54	534830	29.39	1361203	74.81
Northern Cape	153415	46.85	105274	32.15	4081	1.25	48570	14.83	311340	95.07
Free State	392956	43.31	438998	48.39	12467	1.37	28628	3.16	873049	96.23
KwaZulu-Natal	1024024	36.54	793474	28.32	92316	3.29	457153	16.31	2366967	84.47
North West	245345	24.39	397090	39.47	41029	4.08	218032	21.67	901496	89.61
Gauteng	2261437	59.11	1114697	29.14	29396	0.77	322002	8.42	3727532	97.43
Mpumalanga	324061	30.87	403735	38.46	72206	6.88	111834	10.65	911836	86.85
Limpopo	176904	12.31	520506	36.22	110485	7.69	374016	26.03	1181911	82.25
Total	6385128	43.27	4217141	28.58	402106	2.73	2204464	14.94	13208839	89.51

Notes: "don't know" response category excluded.
Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011a)

Access to piped water as the main source of drinking water has improved marginally in the 5 years since 2006 even though the number of people with access has increased (change = 0.9 percentage point). When delineating access to water in the dwelling by province, it is noted that the Western Cape continues to be at the forefront of access with an additional 5.2% of households having access to piped water in their houses. Limpopo province remains at the bottom of the log with a decline in the proportion of household with access to piped water in the house of 22.1% (from 15.8 % to 12.3% in 2011). The North West province also noted a decrease of 17.42% in the proportion of households that had access to piped water in their houses (from 28.65% to 24.4 % in 2011).

In 2011, the percentage of households with water access only in their yards improved to just under half (48.4%) of the households. A considerable percentage of households in the Eastern Cape (29.4%) and North West Province (21.7%) continued to make use of communal taps as their primary source of drinking water with a larger percentage of households making use of communal taps in 2011 (increase of 5.9% and 1.8% respectively). Although a large share of households in Limpopo (26.0%) use communal pipes as their primary source of drinking water, 6.5% fewer households make use of this form of piped water in 2011 compared to 2006. The portions of households (2.7%) that make use of their Neighbour's taps remain largely steady since 2006.

In the Western Cape, Eastern Cape, KwaZulu-Natal, and Limpopo, the numbers and portions of households with access to piped water have increased. In terms of the remaining provinces, access to piped water has decreased by one percentage point on average with the exception of Mpumalanga province which experienced a two percentage point decrease in piped water access between 2006 and 2011.

4.4.1 Distance travelled to the source of piped water

A quarter of the households (25.5%) face this challenge, of having to travel to their primary source of drinking water with the modal distance of less than 200 meters to collect water (12.0%). When assessing distance travelled across the provinces of South Africa, considerable differences are noted. Just over half (50.5%) of households in the Eastern Cape do not have piped water on site or in close proximity compared to the 5.7% in Western Cape that must travel to retrieve drinking water. Other provinces that have a large proportion of their households traveling to their primary source of drinking water include KwaZulu-Natal (34.3%), Mpumalanga (29.5%), and North West province (28.1%).

Table 4-4: Distance travelled to water source, by province 2006

	Less than 200m	Between 201m and 500m	Between 501m to 1 km	More than 1 km	Total that travel
	%	%	%	%	%
Western Cape	3.35	2.31	0.08	0.00	5.74
Eastern Cape	22.16	14.99	9.03	4.33	50.51
Northern Cape	13.53	4.68	0.73	0.47	19.40
Free State	5.09	2.46	0.43	0.10	8.09
KwaZulu-Natal	12.34	13.12	5.46	3.38	34.30
North West	14.87	9.56	2.68	1.02	28.12
Gauteng	6.30	1.98	0.45	0.12	8.84
Mpumalanga	12.82	10.83	4.76	1.11	29.52
Limpopo	27.30	14.57	5.17	1.94	48.97
Total	12.32	8.21	3.36	1.57	25.46

Notes: "don't know" and "unspecified" response category excluded.
Source: Own calculations using weighted GHS 2006 data (Stats SA, 2006)

In 2011, an overall improvement in the distances travelled for those without in-house/yard connections has been achieved since 2006. Just less than a quarter of those households which had access to piped water did not have piped water in their homes or on their properties (23.4%), a decrease of 2.1%. Of these households who did not have access inside their homes in 2011, just under half had to travel less than 200 meters to collect their water with just under 30% having to travel between 201 and 500 meters to their nearest piped water source. The latter category has attained the largest improvements since 2006. Table 4.5 (overleaf) indicates the distances travelled by households to their primary piped water source, by province for 2011.

Table 4-5: Distance travelled to water source, by province 2011

	Less than 200m	Between 201m and 500m	Between 501m to 1km	More than 1 km	Total
	%	%	%	%	%
Western Cape	5.99	1.34	0.03	0.08	7.44
Eastern Cape	25.86	14.40	5.11	3.73	49.10
Northern Cape	13.44	3.37	0.43	0.00	17.24
Free State	4.93	1.51	0.10	0.04	6.58
KwaZulu-Natal	10.69	10.77	5.39	4.13	30.98
North West	17.62	8.28	2.68	0.66	29.24
Gauteng	7.41	0.82	0.13	0.02	8.37
Mpumalanga	15.82	5.92	2.93	0.42	25.10
Limpopo	19.53	15.27	4.04	0.77	39.61
Total	12.61	6.82	2.49	1.41	23.33

Notes: "don't know" response category excluded.
Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011a)

When assessing this variable by province, only three of the nine provinces had less than 10% of their households traveling to get drinking water, no change since 2006. In the Eastern Cape, marginal changes have been noted with half of the households still traveling to their water source. A substantial percent (41.7%) of households in Limpopo province still travel to their primary water source, however this is a 14.9% decreases since 2006. In KwaZulu-Natal, although only about 10% of households travel less than 200meters to their water source, for every 2.6 households that must travel this distance, one household must travel more than a kilometre to their water source. This is down from the 2006 ratio of 3.65 to one household.

4.4.2 Municipally provided water

GHS questions collect information on how households rate the municipal water service they receive. Rating for water occurs on a three item scale (poor, average or good) with not applicable as an alternative option. Rating of water have been analysed in isolation and also in terms of households' payment for the water they receive. This was done in order to ascertain if an association between these two variables exists. Tables 4.6 and 4.7 explore this relationship for 2006 and 2011 respectively.

For those households that received water from municipal sources in 2006, 73.4% of households rated their water service as *good*. Just less than 20% rated the service as *average* and 6.9% rated their water service as *poor*.

Table 4-6: Rating of municipal water service in relation to payment for water, 2006

Payment for water		Good	Average	Poor	Breakdown of payment
Yes	%	79.63	16.30	4.07	65.14
No	%	61.78	26.07	12.15	34.86
Total	%	73.41	19.70	6.89	100.00

Source: Own calculations using weighted GHS 2006 data (Stats SA, 2006)

Among the households that receive municipally supplied water, 65.1% paid for the water they receive. A higher percentage of the households who reported paying for their water identified the quality of the water service as good (79.6%) compared to only 61.8% of households that did not pay for their water reporting similarly. This difference in percentages is statistically significant at a 95 percent significance level (χ^2 = 338608.373, p=0.000).

Compared to 2006, in 2011, a considerably smaller percentage (62.4%, representing a decrease of 11.0 percentage points) of households that utilised water from municipal water rated the water services they received as *good*. Over the period, a larger proportion (28.5%, representing an increase of 8.8 percentage points) of households rated their service as *average* and 9.6% (increase of 2.7 percentage points) rated the service as *poor*. This indicates an overall negative shift in the perceptions of households towards the services they receive.

Table 4-7: Rating of municipal water service in relation to payment for water, 2011

Payment for water		Good	Average	Poor	Breakdown of payment
Yes	%	70.52	22.69	6.79	46.84
No	%	54.68	33.25	12.07	53.16
Total	%	62.36	28.46	9.63	100.00

Source: Own calculations using GHS 2011 data (Stats SA, 2011a)

There has also been a substantial decrease in payment for water, with a 28% decrease in the number of households that pay for the water they use between 2006 and 2011. In 2011, less than half (46.8%) of the households that make use of municipal water paid for the water they utilised, compared to 65.1% in 2006. The reasons why households do not pay for water are not collected in the surveys. However a statistically significant relationship exists (χ^2 = 22527873, p=.000), i.e. between the payment for water and the rating of water supply received: compared to households that did not pay for water, a significantly larger percentage of households that paid for water rated the quality of water supply as good.

4.4.3 Quality of water

Water quality is assessed in terms of how households rate the quality of the water they received, and the need to treat the/this water. Table 4.8 provides information on the four aspects of water quality identified in the GHSs namely *is the water safe to drink*, *is it clear* (turbidity), *is it good in taste* and *is it free from bad smells*. The analysis is again conducted in relation to the payment for water in 2006 and 2011.

Table 4-8: Households ratings of water quality and payment for water, 2006 and 2011

Water Quality			GHS 2006			GHS 2011		
			Payment for water			Payment for water		
			Yes	No	Total	Yes	No	Total
Safe to drink	Yes	Row %	65.21	34.79	100	46.47	53.53	100
		Column %	97.49	97.22	97.39	96.45	97.65	97.09
	No	Row %	62.78	37.22	100	57.12	42.88	100
		Column %	2.51	2.78	2.61	3.55	2.35	2.91
Clear	Yes	Row %	65.18	34.82	100	46.4	53.6	100
		Column %	96.62	96.47	96.57	95.52	96.96	96.29
	No	Row %	64.14	35.86	100	56.43	43.57	100
		Column %	3.38	3.53	3.43	4.48	3.04	3.71
Good in taste	Yes	Row %	65.29	34.71	100	46.4	53.6	100
		Column %	96.31	95.70	96.10	95.02	96.45	95.78
	No	Row %	61.63	38.37	100	55.2	44.8	100
		Column %	3.69	4.30	3.90	4.98	3.55	4.22
Free from bad smells	Yes	Row %	65.25	34.75	100	46.7	53.3	100
		Column %	96.95	96.52	96.80	96.92	97.29	97.12
	No	Row %	62.11	37.89	100	49.94	50.06	100
		Column %	3.05	3.48	3.20	3.08	2.71	2.88

Notes: Category "unspecified" excluded from analysis
Source: Own calculations using weighted GHS 2006 and 2011 data (Stats SA 2006, 2011)

In 2006, 97.4% of households felt the municipal water they receive was safe to drink. Of these households, 65.21% paid for the water they received. Of the 2.6% that felt their drinking water was not safe to drink, 37.2% had not paid for the water they receive. A slightly smaller proportion (96.6%) of households reported that their water was clear in that it had not colour and was free of mud. Of these households, 65.2% paid for the water they received. When looking at households' rating on whether they thought their water was good in taste, 96.1% responded positively and 96.8% of households classified their water as being free from bad smells.

In 2011, 97.1% of households who receive municipal water rated their water as safe to drink. Similar results were achieved for the other three quality variables namely that water was clear in colour, good in taste and free from bad smells (96.3%, 95.8%, and 97.1% of households respectively). An inverse relationship exists between positive ratings on the quality of water and the payment for water received. When assessing the quality of water, of those households that paid for water, the majority rated their water positively: 97.5% of these households classified their water as safe to drink, 96.6% classified their water as clear, 96.3% as good in taste and 96.6% as free from bad smells.

Table 4.9 provides an overview of the need to treat drinking water for the various types of piped water.

Table 4-9: Treatment of drinking water by type of piped water, 2006 and 2011

		GHS 2006					GHS 2011				
Treatment of drinking water		**Piped (house)**	**Piped (yard)**	**Neighbour's tap**	**Communal Stand Pipe**	**Total**	**Piped (house)**	**Piped (yard)**	**Neighbour's tap**	**Communal Stand Pipe**	**Total**
Yes, always	%	10.21	7.88	9.11	7.79	8.98	4.93	1.32	2.34	1.00	3.05
Yes, sometimes	%	5.61	5.02	3.61	5.15	5.28	4.56	4.03	3.09	2.07	3.94
No, never	%	84.17	87.10	87.28	87.06	85.74	90.51	94.65	94.56	96.94	93.01

Source: Own calculations using weighted GHS 2006 and 2011 data (Stats SA 2006, 2011)

It is interesting to note that a larger proportion of household that had piped water in their houses treated the water either always or sometimes when compared to the proportion of households that receive from communal standpipes that treat their drinking water. However this does not account for the reasons why households treat water which are likely to vary.

Over the period, the percentage of households that treat the water they receive decreased by 51.0% since 2006. This could indicate an improved perceived quality of water received or a decrease in the transmission of knowledge of the benefits of additional treatment of water in the home.

4.4.4 Occurrence of interruptions

Interruptions to the water supplied to the household by the municipality are assessed in terms of the household's source of piped water. Table 4.10 provides a breakdown for 2006 and 2011.

Table 4-10: Interruptions to water supply by type of piped water, 2006 and 2011

Water supply interruption in last year**				Piped water type**				
				Piped (house)	**Piped (yard)**	**Neighbour's tap**	**Communal Stand Pipe**	**Total**
2006	Yes	Row	%	37.85	41.17	2.19	18.80	100.00
		Column	%	28.46	45.52	68.34	61.46	38.88
	No*	Row	%	60.51	31.34	0.64	7.50	100.00
		Column	%	71.54	54.48	31.66	38.54	61.12
2011	Yes	Row	%	36.37	37.74	3.13	22.76	100.00
		Column	%	28.85	45.30	40.68	53.28	38.49
	No*	Row	%	56.14	28.51	2.86	12.49	100.00
		Column	%	71.15	54.70	59.32	46.72	61.51

Notes: **category unspecified excluded from analysis
*"No" includes those who responded almost never in GHS 2006
Source: Own calculations using weighted GHS 2006 and 2011 data (Stats SA 2006, 2011)

In 2006, just less than 40% of households that had access to piped water had experienced interruptions in their water supply in the preceding 12 months. Of these households, those which had access in the yard were mostly likely to experience these interruptions (41.2%). This group is closely followed by those who received water in their houses (37.8%). Within each type of piped source, it is evident that a larger proportion of those who receive piped water in their house or in their yards did not experience water interruptions in the previous year (71.5% and 54.5% respectively). In contrast, roughly three fifths of those households who made use of their neighbour's taps or communal taps indicated that they had experienced interruptions in the previous year (68.3% and 61.6% respectively). The relationship between piped water source and occurrence of interruptions is statistically significant (χ^2 = 581799.948, p=0.00).

There has been little change (1% improvement) in the share of households with piped water which experienced interruptions in water supply between 2006 and 2011. There has however been a substantial shift in the proportion of interruptions by source of piped water. Of the households that experienced interruptions in the preceding year, those who had access in the yard still experienced the greatest proportion of these interruptions (37.7%) followed by those who have access to piped water in their houses (36.4%). However, decreases in each category were noted. Those households whose primary source of drinking water was obtained from communal stand pipes now comprise 22.8% of all households that experienced interruptions. This is an increase of 21.1% since 2006.

Among households that made use of their neighbour's taps or communal taps, a smaller share indicated they had experienced interruptions in 2011 compared to 2006. A larger share of households that utilised their neighbour's taps indicated in 2011 that they had not experienced water supply interruptions in the past year (59.3%), an improvement of 27.7 percentage points since 2006. Just over half of those households that utilised communal pipes indicated that they had experienced interruptions in the previous year (53.3%), an improvement of 8.2 percentage points since 2006.

4.5 Summary of findings

This chapter assessed changes between 2006 and 2011 in various aspects of water specific characteristics, namely, access to drinking water, rating of municipal water service, quality of potable water and occurrence of interruptions. The descriptive analysis revealed an uneven progress in the nature, quality, and reliability of water access over this five-year period.

The overall access to piped water has increased only marginally since 2006. Improvements were noted in four of the nine provinces. However, provinces such as Limpopo and the North West province recorded a substantial decrease in the proportion of households with access to piped water in the house. With the exception of the Eastern Cape and the North West province, there has been an overall decrease in the share of households that make use of communal stand pipes as their primary source of potable water.

However, over the period, a smaller percentage of households travelled longer distances to obtain their drinking water. Most of the households that did not have access in their homes walked less than 200 meters to obtain their water. Again, these improvements are not noted in all provinces, larger portions of households in Eastern Cape and North West province travelled to their primary source of drinking water. Although substantial improvements have been noted in provinces such as Limpopo province, just over 40% of households had still travelled to their primary source of drinking water. Further development needs to occur.

There was an overall decrease in how households rated the quality of municipal water service. Coupled with this, there was a substantial decrease in the proportion of households that pay for the water they utilise. However, most households in 2011 continued to rate their water quality as being safe to drink, clear in colour, free from bad smells and good in taste, with more than a 50% decrease in the proportion of households that treated their water in 2011.

Over the period, there was a marginal improvement in the overall occurrence of water interruptions by households. When looking at this from the various types of piped water, although households which had water access in the yard and in their houses still experienced the greatest proportion of these interruptions in 2011, the portions which experienced interruptions have decreased since 2006. As a result, households whose primary source of drinking water was obtained from communal stand pipes or a neighbour's tap formed a larger share of all households that experienced interruptions in 2011.

Chapter Five

5. Econometric Findings and Discussion

5.1 Introduction

This chapter will first describe the sample used in the regression analysis, namely children under the age of five years and explores the distribution of the incidence of diarrhoeal disease. The chapter then considers the bivariate descriptive statistics in order to establish a base for the relationship between water access, water quality and the various household-specific correlates of child health. These household-specific variables along with child-specific variables form control variables in the probit regressions featured in this chapter. This is done with the aim of determining whether water access and water quality are independently related to child health, after controlling for other likely correlates. Results from the multivariate econometric models will be presented, compared, and discussed in relation to the literature reviewed in chapter 2.

5.2 Population characteristics of the sample

In 2011 9.9% of the population in South Africa was under the age of five years. The mean age of the under-five population is two years of age and there was an equal distribution of males and female children in this group.

Table 5-1: Population characteristics of children under five years

		Unit	2011
Under 5	Total under 5	Children	4979615
	Portion of population	%	9.90
	Mean age	Years	2.00
	Standard error	S.E	1.42
Gender	Male	%	50.36
	Female	%	49.64

Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011)

5.3 The burden of diarrhoea in South Africa

The incidence of diarrhoea is assessed across two age cohorts, namely those under the age of five years and those five years and older in order to ascertain the burden of disease that falls on children under the age of five in South Africa. In 2011, of the reported diarrhoea disease incidences, 27.7% were experienced by children under the age of five years indicating that the burden of this illness therefore falls primarily on the very young. This corresponds to 1.06% of the under-five population reporting having experienced diarrhoea in the month preceding the surveying of the GHS. For those aged five and over, diarrhoeal disease was reported by only 0.30% of the population. This shows that while children under the age of five years make up just less than 10% of the population, they experience a disproportionate share of the illness.

Table 5-2: Incidence of diarrhoea in the past month, by age cohort, 2011

	2011		
Suffer from Diarrhoea in past month (yes)	**Age cohort**		**Total**
	Under five years	**Five years and over**	
Breakdown of the burden of diarrhoeal disease (%)	27.67	72.33	100
Within Age cohort %	1.06	0.30	0.38

Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011)

5.4 Differences in water access and water quality by households

As an initial step in the development of the models that predicts the probability of childhood diarrhoeal disease, Table 5.3 (overleaf) presents the bivariate analysis of the water-related variables and household-level explanatory variables with the incidence of childhood diarrhoeal disease. Coefficients are within group portions (%) of children that had experienced diarrhoeal disease and Pearson correlation p-values are provided. While this test of correlation is favoured, it provides some preliminary indication of the strength of the correlation between these independent variables and incidence of diarrhoeal disease before conducting the more comprehensive multivariate regression analysis. Values are reported at three decimal places given their magnitude.

Table 5-3: Bivariate analysis

		Diarrhoeal disease (Yes)	Pearson Correlation P-value
Key water-related explanatory variables			
Piped water in the house/on site		0.011 (0.002)	0.497
Treatment of water		0.002 (0.001)	0.003***
Quality	Safe	0.011 (0.001)	0.028**
Quality	Turbidity - Clear	0.010 (0.001)	0.648
Quality	Smell	0.011 (0.001)	0.029**
Quality	Taste	0.010 (0.001)	0.247
Household-level explanatory variables			
Age of household head	Under 18	0.000 (0.000)	0.838
	18-25	0.014 (0.006)	
	26-39	0.012 (0.003)	
	Older than 40	0.010 (0.001)	
Male household head		0.010 (0.002)	0.818
Household size	5-10	0.012 (0.002)	0.419
	10-14	0.009 (0.002)	
	15+	0.012 (0.005)	
Household expenditure	Less than R1799	0.012 (0.002)	0.325
	Between R1799 and R4999	0.008 (0.002)	
	Greater than R5000	0.011 (0.003)	
Access to a flush toilet	Yes	0.012 (0.002)	0.217

Notes: Weighted data. Standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01
Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011)

At a bivariate level, treatment of water and positive ratings on the quality variable of 'safety' and 'smell' appear to be correlated with childhood diarrhoeal disease. These variables will be tested at the multivariate level, accounting for a number of other control variables, to determine if they significantly predict childhood diarrhoeal disease.

5.5 Multivariate regression results

A probit regression was conducted using groups of variables identified in Chapter Two as key explanatory variables in a stepwise-like form. This was done to assess the impact of each predictor variable with the dependent variable. The probability that a child experienced diarrhoea was the dependent variable in the estimation. Two models were created where variables were selected based on their individual significance and the overall model fit. Given that access to sanitation in the form of flush toilets is highly correlated with access to piped water, two separate models were estimated to reduce multicollinearity in the regressions and to test the robustness of the models. Model 1 is made up of a number of control variables and the sanitation variable (access to a flush toilet). Model 2 provides a full model comprising all the control variables, and the key water variables considered in this study, but it excludes the sanitation variable. The sample for the analysis includes all children under the age of five years in the 2011 GHS and is weighted using the Stats SA weights. Regression results for these models are presented in Table 5.4. (overleaf).

The marginal effects for the variables included in Model 2 are provided in Table 5.5. Values are reported at three decimal places given their magnitude. Only the significant findings will be discussed.

Table 5-4: Probit estimation of the probability of diarrhoeal disease in children under the age of five, 2011

	Model 1	Model 2
Gender (Male)	0.02 (0.10)	0.02 (0.10)
Age	-0.10*** (0.03)	-0.10*** (0.03)
Western Cape	0.04 (0.16)	0.02 (0.16)
Eastern Cape	-0.03 (0.18)	-0.01 (0.18)
Free State	-0.25 (0.2)	-0.23 (0.19)
KwaZulu-Natal	-0.59** (0.23)	-0.58*** (0.22)
North West	0.05 (0.20)	0.07 (0.19)
Mpumalanga	-0.1 (0.2)	-0.08 (0.19)
Limpopo	-0.03 (0.20)	-0.02 (0.20)
Urban informal	0.04 (0.20)	0.07 (0.20)
Tribal area	-0.35* (0.19)	-0.28* (0.17)
Rural	-0.70** (0.34)	-0.68* (0.36)
White	-0.39 (0.35)	-0.39 (0.35)
Coloured	-0.01 (0.16)	0.00 (0.16)
Indian	0.05 (0.37)	0.05 (0.37)
Household size	-0.03 (0.03)	-0.03 (0.03)
Age of household head	0.00 (0.00)	0.00 (0.00)
Male household head	-0.06 (0.10)	-0.06 (0.10)
Household expenditure less than R1799	0.20** (0.1)	0.21** (0.10)
Access to a flush toilet	-0.11 (0.20)	- -
Piped water in the house/on site	- -	-0.02 (0.17)
Treatment of water	-0.65*** (0.25)	-0.65*** (0.25)
Turbidity - Clear	-0.21 (0.16)	-0.21 (0.16)
Constant	-1.42 (0.29)	-1.52 (0.27)
Pseudo R-Squared	0.06	0.06
Wald Chi-Squared	2.99	2.97
Percent correctly predicted	99.04	99.05
Unweighted sample size	9057	9190

Notes: Weighted data. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01
Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011)

Table 5-5: The probability of diarrhoeal disease in children under the age of five, 2011, marginal effects after probit estimates

	Model 2
Gender (Male)	0.000 (0.002)
Age	-0.002*** (0.001)
Western Cape	-0.002 (0.001)
Eastern Cape	0.000 (0.003)
Free State	-0.003 (0.002)
KwaZulu-Natal	-0.007*** (0.002)
North West	0.001 (0.004)
Mpumalanga	-0.001 (0.003)
Limpopo	0.000 (0.003)
Urban informal	0.001 (0.004)
Tribal area	-0.005* (0.003)
Rural	-0.006* (0.001)
White	-0.005 (0.002)
Coloured	0.000 (0.003)
Indian	0.001 (0.007)
Household size	0.000 (0.000)
Age of household head	0.000 (0.000)
Male household head	-0.001 (0.002)
Household expenditure less than R1799	0.004** (0.002)
Piped water in the house/on site	0.000 (0.003)
Treatment of water	-0.006*** (0.001)
Turbidity – Clear	-0.005 (0.004)

Notes: Weighted data. Robust standard errors are presented in parentheses. The marginal effects for continuous variables are calculated as a change in the probability of the instantaneous change in the continuous variable. For binary variables the effect is calculated for a discrete change in the dummy variables.
*p<0.1, **p<0.05, ***p<0.01
Source: Own calculations using weighted GHS 2011 data (Stats SA, 2011)

Among the control variables, age of child, the province of KwaZulu-Natal, living in tribal and rural areas, and a monthly household expenditure of less than R1799 show significant associations with incidence of childhood diarrhoea. All else being equal, a 1 year increase in age decreases the probability of childhood diarrhoeal disease by 0.002. The negative and significant association of age is expected given that immunity increases with age (Ygberg & Nilsson, 2012). Living in a household that has a monthly household expenditure of less than R1799 increases the probability of child diarrhoeal disease by 0.004, ceteris paribus. This means that young children living in households where expenditure is below the rough estimate for the household poverty line, have a greater probability of experiencing diarrhoeal disease than children living in richer households. The positive relationship between these two variables is not unexpected since poorer households are less likely than richer households to have access to the good healthcare services, health protecting resources such as living in environmentally safer areas and other factors such as access to food (North Carolina Institute of Medicine Task Force on Prevention, 2009).

In the 2011 wave of the GHS, no cases of under-five diarrhoea were reported in the Northern Cape. The variable for Northern Cape was therefore dropped from the regression models. Living in the province of KwaZulu-Natal decreases the probability of child diarrhoeal disease by 0.007 when compared to living in Gauteng province. The significant association noted suggests that there is some characteristic in this province that differs from that of the Gauteng province (the omitted provincial category) that is not present in any other province and not accounted for in this model. It may be that given the high rates of HIV in the province, greater efforts have been made to encourage better nutrition and healthcare practices in this province. Alternatively, it may be that the natural water sources in KwaZulu-Natal are less polluted given that fewer industries are based in KwaZulu-Natal (and therefore less chance of polluting the water reserves) compared to Gauteng.

While one may expect that people living in urban areas would have greater access to services and therefore lower levels of communicable diseases, this study found that children residing in tribal and rural areas had a significant negative association with the incidence of under-five diarrhoea. Living in tribal and rural areas decreases the probability of child diarrhoeal disease by 0.005 and 0.006 respectively when compared to the reference group of living in an urban formal area. A possible explanation for this is that the lower population density in these areas deters the spread of communicable diseases such as diarrhoea. The remaining control variables, while having the expected sign, were not found to be significant predictors of child diarrhoea.

A number of additional variables were considered in earlier models but were found to be highly insignificant. These variables did not add to the explanatory power of the models and were subsequently excluded from the analysis. In particular, maternal presence and maternal education, identified as important factors determining child health in Chapter Two, were tested and found not to be significantly related to the probability of diarrhoea in young children.[5] Information on the education of the child's mother was not collected in the GHS 2011, and maternal education was therefore proxied by the highest level of female education in the household. In the case of maternal education, this may be partly because of the proxy variable used. In the case of maternal presence, it may be that extended household formation (and the presence of grandparents, aunts or other family members) mitigates against the negative effects of maternal absence on child health. Household size was also not found to be statistically related to child diarrhoea. Other variables tested in earlier models and found to have an insignificant relationship with the probability of child diarrhoea were distance travelled by people who did not have water access on site, and whether the child had gone hungry often/always in the past year (as a proxy for child nutrition).

The main variables of interest for this study concern those related to the household's access to and quality of water. The relationship between household access to a flush toilet and childhood diarrhoea was tested in Model 1 (reported in Table 5.4). Although the coefficient is negative (as would be expected), it is not statistically significant. A possible reason for this may be that while a substantial proportion of households which include young children do not have access to flush toilets, they may have access to other forms of sanitation facilities such as chemical toilets. This would limit the spread of the pathogens from faeces that causes diarrhoeal disease.

Model 2 tests the relationship between access to piped water and incidence of childhood diarrhoea, and again no significant association was found. The perceived quality of water is also not a significant correlate of the likelihood of diarrhoea among young children. In both models, self-reported positive ratings of water quality (the water was regarded as "clear") were not found to be significantly related to child diarrhoea. The only significant relationship for the water-related variables was that of treatment of the water used. Households that treat their water were statistically less likely to report cases of child diarrhoea than those households that did not treat their drinking water. Treating household water reduces the probability of child diarrhoea by

[5] These variables were not significant even when no other controls were included in the regressions.

0.006. This suggests that while many households may perceive their water to be of a good quality, the water may in fact be substandard. This variable is highly significant indicating that any differences among children are not due to chance.

5.6 Discussion

When considering the overall incidence of diarrhoeal disease, nearly 30% of all reported cases occurred in children under the age of five, although children in this age group accounted for only 9.9% of the total population. This indicates that the burden of this disease falls disproportionately on the young.

The literature presented in Chapter Two emphasised the importance of maternal education in determining children's health. However, in this empirical study, maternal presence and a proxy for maternal education were not found to be significant correlates of child diarrhoea. This may reflect the complex nature of household formation in South Africa, the high prevalence of extended families, and the provision of childcare by people who are not the child's biological parents, particularly in the context of migration patterns in the country (Bennett, Hosegood, Newell, & McGrath, 2014). These factors may influence the relationship between maternal characteristics and the development of children. Gender of household head was also not found to be a significant predictor of childhood diarrhoeal disease. This again may suggest that the functioning of families in South Africa is different to that described in studies from other countries.

Given the problems associated with using income data in the GHS, household expenditure was used as a proxy of economic standing. It also serves as a proxy for household choice in terms of a household's investments decisions, including those related to preventative behaviour against disease and choice of healthy environment. A comparison of wealth impacts on the probability of child diarrhoea suggests that children living in poorer households are worse off than those living in richer households. The significant negative correlation, coupled with the fact that poor households are expected to be less likely to be afforded many choices, suggest that interventions specifically targeting children living in the poorest households may substantially reduce the incidence of childhood illness. Furthermore, given the wealth classification used in this study – the rough household poverty line – findings indicate that income grants targeted at households living below the poverty line may contribute to reducing the incidence of diarrhoeal disease amongst children. The presence of and access to healthcare services is another likely correlate of diarrhoeal disease that was not included in the models due to the limited availability of data. It is likely that this does have an impact on family health in general and its effect may be included in the associations with some of the variables, and particularly household expenditure (richer households would have access to better healthcare services).

A particular focus of the study was to assess whether access to piped water is correlated with the risk of diarrhoeal disease among young children. Given that a substantial proportion of households already have access to some form of piped water, it was more appropriate to narrow the focus to the ideal source of water access, either within the household or on site. Surprisingly, access to water from these sites was not found to be a significant predictor of childhood diarrhoeal disease. Nonetheless, there are a number of indirect benefits that could impact the health of a child. Improving the proximity of water access would reduce the time spent by mothers (and other household members) in collecting water, allowing for this time to be used more productively, such as looking after their children or engaging in income-generating activities for the mother. For the child, studies have found that reducing the time spent collecting water increases school attendance particularly for girls who often take on this role (Fogden, 2009; Nauges & Strand, 2013). Other benefits include the reduced potential for contamination that occurs when households do not have water access on site, as discussed in Chapter Two.

In 2011, the overwhelming majority of households rated their municipal water positively on all four characteristics of water quality. Perceived water quality was, however, not found to be a significant predictor of diarrhoeal disease in the regression analysis (earlier models also explored the relationship for the remaining quality variables and found similar insignificant findings). However, young children living in households that treated their water were found to have a significantly smaller probability of experiencing diarrhoea. While the reason why households treat their water was not explored, possible reasons for this may be that these households felt their water was not safe to be consumed without treatment or education campaigns were effective in conveying the benefits of treating water for household consumption, regardless of how they personally assessed its quality. Findings from the study suggest that even if households assessed the quality of their water as good, the probability of child diarrhoea would have been reduced had they treated their drinking water. Fodgen (2009) predicts that in the near future, there will be a restructuring in the way safe water is provided. Purifying household water at the point of use will take on a more substantial role in improving access to safe drinking water globally.

The quality of water itself was not tested in this model due to a limited availability of data. Instead, this study looked at households' perception of the quality of the water they obtain. While this variable was not found to be significantly associated with diarrhoeal disease, nearly all households rated the aesthetic parameters of their water positively. Given that 24% of municipalities were found to be in need of urgent attention relating to their water quality levels, with a further 21% being in need of some attention, it may be that households' ability to discern the quality of their water may be limited. This could be due to the fact that diarrhoea causing pathogens present in the water are not easily identifiable though sensory/aesthetic measures (Mechenich & Andrews, 1993), indicating that the ability to determine the bacterial quality of water using such measures may be unsuitable.

5.7 Conclusion

This chapter explored the probability of child diarrhoea using multivariate regression analysis to identify possible correlates. In relation to Mosley and Chen (1984) framework presented earlier, this study finds that a combination of person level (child's age), household level (household expenditure and household's decision to treat their water) and community level (province of residence, living in KwaZulu-Natal in particular and living in a non-urban environment, traditional or rural area) were significantly related to the probability of child diarrhoea. Considering that the other water-related variables (on-site piped water access and households sensorial perceptions of water quality) were not found to be significant predictors of childhood diarrhoea and the decision to treat the water was found to be a significant predictor of childhood diarrhoea, interventions to improve end-use purification must be explored as an effective means to reducing the incidence of childhood diarrhoea.

Chapter Six

6. Summary and Conclusion

6.1 Introduction

The aim of this study was to map changes in water access and water quality and determine if these factors are able to predict the probability of childhood diarrhoea in South Africa. While there have been a number of South African studies that have explored access to water, there has been limited work that has focussed on access by households that house the very young. Additionally, there has been extensive international literature that has explored the impact of water access and quality on childhood diarrhoea, however there has been substantially less work on this topic from South Africa. In particular, there are very few studies that have explored households' perceptions of water services and water quality in South Africa. This concluding chapter draws together the themes that have been explored in the preceding chapters. In addition, this chapter highlights any limitations and barriers to the study, and finally to discusses how the findings might inform policy considerations and further research.

6.2 Assessment of fulfilment of objectives

As a means of assessing whether the objectives of this dissertation are met, this section revisits and explores each research question.

i. ***How has the level of access and quality of municipally provided water changed in South Africa between 2006 and 2011?***

South Africa has made remarkable strides in affording access to water for the majority of its population that previously lacked access. In the five years since 2006, overall access to drinking water proximity to water source, and the occurrence of water supply interruptions have improved. However, overall numbers mask the uneven progress that has been achieved across the regions of South Africa.

Findings from the General Household Surveys (GHSs) indicate that while a large proportion of households report access to piped sources of water, access within the home is still remarkably low in some regions. In particular, in 2011 only 31% of households in the Eastern Cape had access to piped water in their homes and just over 40% of households in Limpopo reported travelling to their primary source of drinking water. In the regression analysis, on-site access to drinking water was not found to significantly predict the probability of diarrhoea in children. Nonetheless, this remains an important developmental objective given the various benefits that accrue from it.

ii. ***Among the households that have access to the different types of piped water, what is the quality of this water and how has this quality changed from 2006 to 2011?***

Ratings of the quality of municipal water services have fallen since 2006 coupled with a considerable decrease in the number of households that pay for the water they utilise. Reliability of water provision remains an issue of concern with two in five households having experienced interruptions of longer than two days in the year preceding the surveying of the GHS 2011.

iii. ***Is there a relationship between access to water and the quality of piped water received in a household, and the health of children, as measured by the incidence of diarrhoeal disease?***

Children under the age of five bear the burden of diarrhoeal disease in South Africa, with almost 30% of all cases being reported in this age group. Economic status was found to be a significant and negative correlate of the probability of child diarrhoea. Maternal characteristics (the presence of the child's mother and a proxy for maternal education), which are highlighted in international studies as key factors influencing child health, were not found to be significant correlates of child diarrhoea in this study. This attests at least in part to the complex nature of household formation in South Africa, and the presence of care-givers of children who need not be the child's mother. Environmental variables of province and geographic type (urban/rural) were found to significantly predict the incidence of child diarrhoea. The gender of the child was not found to be a significant correlate for childhood diarrhoea. However age was a significant correlate, with the likelihood of diarrhoea decreasing among children as they approach five years of age.

Household reports on the aesthetic quality of water were extremely high for both 2006 and 2011. This variable was not found to be a significant predictor of diarrhoeal disease. Of those households that treat the water they use, the largest portions are those that have piped water in their homes. A key finding of this study is that young children living in households that treated their water were found to have a significantly smaller probability of experiencing diarrhoea.

The findings of this study cannot be read in isolation. Cognisance must be taken of the limitations of this study and uncertainty associated within the field of health and therefore with this study as well.

6.3 Limitations

Results and analysis contained in this study rely heavily on existing data. In accepting the data, however, it must be assumed that the information obtained is reliable and correct. Particular limitations relating to the use of data from the GHS include that questions were dependent on one member of the household answering questions for the entire household. Household information is therefore limited to the knowledge of the respondent and this may result in the under-reporting of illness.

The use of self-reported data is related to a number of potential biases such as social desirability, where respondents provide the socially acceptable information particularly for sensitive questions. In the context of this study, questions such as payment for water services may be influenced by this form of bias. Other sources of bias could be recall and attribution amongst others. Attribution bias occurs when respondents pre-determine the cause of a particular outcome and therefore place emphasis on that cause. For example if a respondent believed that the source of their child's diarrhoea was caused by inferior water quality, they inaccurately report the quality of their water as a means of placing emphasis on this predetermined cause. Should these biases be present, they may influence the outcome variable that was analysed. However, it is assumed that the large size of the sample would minimise any influence that these biases may have.

The field of health is a multifaceted and dynamic. There are many factors, other than the person-level, household-level and environmental factors included in this study that may influence health outcomes. Biological factors, person-level factors such as hygiene practices and resilience, and contextual factors such as access to health education programmes, are likely to influence child health outcomes but were not included in this study due to due to limitations in the data.

With these limitations in mind, this study can now take a broader view of barriers to addressing child health in South Africa.

6.4 Addressing barriers to child health

A number of key barriers will need to be addressed if the burden of childhood diarrhoeal disease is to be successfully reduced in South Africa. Oral rehydration has been recognised as the preferred treatment of diarrhoeal disease (Wittenberg, 2012). The premise of this recommendation is the availability of water that is of a good quality. Treatment of diarrhoeal disease could potentially be ineffective if households do not have access to water close to their homes as well as water of a high quality.

The MDG target related to water is considered to be achieved given that by 2010 almost 93% of the population had access to some form of drinking water. However, the South African Government should shift focus towards some of the other goals that lag far behind, such as the targets relating to basic sanitation. It is not argued that addressing other pressing needs should be halted but rather that focus should not be lost in terms of continuing efforts to improve access to and quality of drinking water.

6.5 Recommendations and areas for further research

Further studies need to be conducted to look at some of the questions arising from this study as well as to further clarify the results presented in this study. Provincial differences were noted in terms of the incidence of childhood diarrhoeal disease. While potential reasons for this difference were discussed, more research is needed to explore these findings further. Given the significance of treating drinking water, this also warrants further examination, including whether existing education programmes are encouraging households to treat their water and whether more can be done to reduce the burden of childhood diarrhoea.

6.6 Conclusion and policy implications

The objective of the study was to determine whether the water-related aspects of access and user-reported quality significantly predict the probability of under-five diarrhoeal disease. The intention was that the analysis, conclusion, and recommendations would assist policy makers and guide future research related to the best options for reducing the burden of childhood disease, as well as to initiate a move towards considering the complete perspective when providing basic services. That is looking at the reliability of service delivery, the quality of water, and the proximity of water access.

Coverage rates alone may underestimate the state of water access if services are not offered reliably and water provided is not of a good quality. A Report by the Council for Scientific and Industrial Research and Construction and Industry Development Board (2007) indicates that the water infrastructure may not be functioning properly due to maintenance problems. This suggests that uncertainty regarding water availability is a continuing challenge for households.

The main conclusion of the study derives from the treatment of household water consumed. The significant finding on this variable highlights the importance of disease-related social policy for reducing child morbidity. End-use treatment is highly cost effective, making this an ideal intervention for improving child health outcomes. Awareness can be achieved through public education programmes on prevention and treatment both through larger media campaigns as well as on-the-ground interventions. Given that diarrhoeal disease, nutrition and other communicable diseases are closely related, and for greater outreach and efficient use of public funds, integrated campaigns that cover a range of related topics can be employed. In a study conducted by Dippenaar et al. (2005) caregiver knowledge and use of effective treatment were extremely high; however less than half of the caregivers were able to correctly administer the treatment. It is therefore imperative that firstly healthcare workers are trained to provide information on prevention and treatment of diarrhoeal disease and secondly that education programmes are both well targeted for the sample population and comprehensive.

Reviewing the various government publications related to water indicate that a disproportionate emphasis is placed on coverage with limited consideration of the reliability and quality of services. While international targets such as the MDG's incorporate aspects beyond access, progress reports tend to focus on access when determining if such targets have been met. With the deadline for the MDG's coming to an end in 2015, there is much discussion as to what happens next. South Africa has successfully been able to achieve its MDG target in terms of improving access; the second part of the goal that speaks to *safe water* should, together with ensuring reliable services, be prioritised going forward. If the true intention of the MDGs is to be realised, that is, to improve the lives of people, efforts should be made to increase the proximity of water access and improve the quality of water that is provided through piped access.

Policy implications point towards educating households, regardless of their water source, on the various sources of contamination and end use purification methods that can be adopted to ensure the health of their children. Regulations related to water quality need to better enforced. The initiation of the Blue Drop Report by the DWAF is encouraging; however this report indicates that many municipalities fall short of the minimum standards. The report should be used as a tool to highlight the possible causes of non-compliance at the level of the municipality and to plan how best to intervene to improve current conditions. Enhancing the monitoring programmes at the level of the province may put additional pressure on municipalities to address problems of water quality.

This dissertation can conclude that the environmental factors of access to water and water quality act as predictors of childhood health in South Africa. In order to address such predictors, social policy that relies on coverage rates alone may prove to be ineffective as these rates underestimate the state of water access if services are not offered reliably and water provided is not of a good quality. Failure to do so may result in increasing rates of childhood diarrhoeal disease.

References

Abong'o, B.O., & Momba, M.N.B. (2008). Prevalence and potential link between e. Coli o157:H7 isolated from drinking water, meat and vegetables and stools of diarrhoeic confirmed and non-confirmed hiv/aids patients in the amathole district – south africa. *Journal of Applied Microbiology, 105*(2), 424-431. doi: 10.1111/j.1365-2672.2008.03756.x

Ahmad, N., Safdar, S., & Sher, F. (2012). Analysis of income and economies of scale effect on household demand in pakistan using pslm data. *Interdisciplinary journal of contemporary research in business 2*(12).

Ahmed, A.K., Ferring, A., & Ruiz, L.I. (2005). *Manual on environmental health indicators and benchmarks*. Washington: Science and Human Rights Program and American Association for the Advancement of Science.

Alexander, P. (2010). Rebellion of the poor: South africa's service delivery protests–a preliminary analysis. *Review of African Political Economy, 37*(123), 25-40.

Anderson, B.A., Phillips, H.E., Wentzel, M., & Romani, J.H. (2010). Awareness of water pollution as a problem and the decision to treat drinking water among rural african households with unclean drinking water: South africa 2005. Pretoria: HSRC.

Arene, C., & Anyaeji, C. (2010). Determinants of food security among households in nsukka metropolis of enugu state, nigeria. *Pakistan Journal of Social Sciences, 30*(1), 9-16.

Assis, A.M., Barreto, M.L., Santos, L.M., Fiaccone, R., & da Silva Gomes, G.S. (2005). Growth faltering in childhood related to diarrhea: A longitudinal community based study. *European Journal of Clinical Nutrition, 59*(11), 1317-1323.

Baer, R.D., & Madrigal, L. (1993). Intrahousehold allocation of resources in larger and smaller mexican households. *Social Science & Medicine, 36*(3), 305-310.

Balfour, T. (2006). Challenges of water quality management in populations with high prevalence of human immunodeficiency virus. *Journal of Development Perspectives, 2*(2), 208-220.

Bank, L., Minkley, G., & Kamman, E. (2010). *Poverty, vulnerable groups and basic service delivery*. East London, RSA: Fort Hare Institute of Social and Economic Research.

Bennett, R., Hosegood, V., Newell, M.-L., & McGrath, N. (2014). Understanding family migration in rural south africa: Exploring children's inclusion in the destination households of migrant parents. *Population, Space and Place*, n/a-n/a. doi: 10.1002/psp.1842

Bessong, P.O., Odiyo, J.O., Musekene, J.N., & Tessema, A. (2009). Spatial distribution of diarrhoea and microbial quality of domestic water during an outbreak of diarrhoea in the tshikuwi community in venda, south africa. *Journal of Health, Population, and Nutrition, 27*(5), 652-659.

Black, R.E., Cousens, S., Johnson, H.L., Lawn, J.E., Rudan, I., Bassani, D.G., . . . Mathers, C. (2010). Global, regional, and national causes of child mortality in 2008: A systematic analysis. *The Lancet, 375*(9730), 1969-1987.

Black, R.E., Morris, S.S., & Bryce, J. (2003). Where and why are 10 million children dying every year? *Lancet, 361*(9376), 2226-2234. doi: 10.1016/s0140-6736(03)13779-8

Boadi, K.O., & Kuitunen, M. (2005). Childhood diarrheal morbidity in the accra metropolitan area ghana: Socio-economic environmental and behavioral risk determinants. *World Health and Population*, 2-13. doi: doi:10.12927/whp.2005.17646

Bobonis, G.J., Miguel, E., & Puri-Sharma, C. (2006). Anemia and school participation. *Journal of Human Resources, XLI*(4), 692-721. doi: 10.3368/jhr.XLI.4.692

Bozkurt, A.I., Ozgur, S., & Ozcirpici, B. (2003). Association between household conditions and diarrheal diseases among children in turkey: A cohort study. *Pediatrics international, 45*(4), 443-451.

Burney, N.A., & Khan, A.H. (1991). Household consumption patterns in pakistan: An urban-rural comparison using micro data. *The Pakistan Development Review, 30*(2), 145-171.

Centres for Disease Control and Prevention. (2008). Household water use and health assessment spanish town, jamaica water safety plan. Atlanta: U.S. Department of Health and Human Services.

Charmarbagwala, R., Ranger, M., Waddington, H., & White, H. (2004). The determinants of child health and nutrition: A meta-analysis. Washington, DC: World Bank.

Choi, S.Y. (2003). Mechanisms of racial inequalities in prevalence of diarrhoea in south africa. *Journal of Health, Population and Nutrition, 21*(3), 264-272.

Clasen, T., Roberts, I., Rabie, T., Schmidt, W., & Cairncross, S. (2009). Interventions to improve water quality for preventing diarrhoea. *Cochrane Database of Systematic Reviews*(3). doi: 10.1002/14651858.CD004794.pub2.

Clasen, T., Schmidt, W.-P., Rabie, T., Roberts, I., & Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: Systematic review and meta-analysis. *British Medical Journal, 334*(7597), 782-782. doi: 10.1136/bmj.39118.489931.BE

Council for Scientific and Industrial Research, & Construction and Industry Development Board. (2007). The state of municipal infrastructure in south africa and its operation and maintenance; an overview. Pretoria: CIBD.

Cummins, S.K., & Jackson, R.J. (2001). The built environment and children's health. *Pediatric Clinics of North America, 48*(5), 1241-1252.

Curtis, V., Cairncross, S., & Yonli, R. (2000). Domestic hygiene and diarrhoea - pinpointing the problem. *Tropical Medicine & International Health, 5*(1), 22-32.

De Coning, C., & Sherwill, T. (2004). An assessment of the water policy process in south africa (1994 to 2003). Pretoria: Water Research Commission.

Devoto, F., Duflo, E., Dupas, P., Pariente, W., & Pons, V. (2011). Happiness on tap: Piped water adoption in urban morocco. *American Economic Journal: Economic Policy, 4*(4), 68-99.

Dippenaar, H., Joubert, G., Nel, R., Bantobetse, M., Opawole, A., & Roshen, K. (2005). Homemade sugar-salt solution for oral rehydration: Knowledge of mothers and caregivers: Original research. *South African Family Practice, 47*(2), 51-53.

DWA. (2010). Blue drop report 2010 - south african drinking water quality management performance. Pretoria: Department of Water Affairs.

DWA. (2013). National water policy review (pp. 9). Pretoria: Department of Water Affairs and Sanitation.

DWAF. (1994). *Water supply and sanitation policy*. Cape Town: Department of Water Affairs and Forestry.

DWAF. (1996). *South african water quality guidelines*. Cape Town: Department of Water Affairs and Forestry.

DWAF. (1998). Quality of domestic water supplies. Pretoria: DWAF, DOH, Water Research Commission.

DWAF. (2003). Strategic framework for water services: Water is life, sanitation is dignity. Pretoria: Department of Water Affairs and Forestry.

DWAF. (2004). A history of the first decade of water service delivery in south africa 1994 to 2004: Meeting the millenium development goals. Pretoria: Department of Water Affairs and Forestry.

DWAF. (2005). A drinking water quality framework for south africa. Pretoria: Department of Water Affairs and Forestry.

El-Gilany, A.H., & Hammad, S. (2005). Epidemiology of diarrhoeal diseases among children under age 5 years in dakahlia, egypt. *Eastern Mediterranean Health Journal, 11*(4), 762-775.

Ergin, F., Okyay, P., Atasoylu, G., & Beser, E. (2007). Nutritional status and risk factors of chronic malnutrition in children under five years of age in aydin, a western city of turkey. *Turkish Journal of Pediatrics, 49*(3), 283-289.

Esrey, S.A. (1996). Water, waste, and well-being: A multicountry study. *American Journal of Epidemiology, 143*(6), 608-623.

FAO, WFP, & IFAD. (2012). State of food insecurity in the world. Rome: Food and Agriculture Organisation of the United Nations.

Fink, G., Günther, I., & Hill, K. (2014). Slum residence and child health in developing countries. *Demography, 51*(4), 1175-1197. doi: 10.1007/s13524-014-0302-0

Fogden, J. (2009). *Access to safe drinking water and its impact on global economic growth*. Bothell, WA: HaloSource.

Fratamico, P.M., Smith, J.L., & Brogden, K.A. (2009). *Sequelae and long-term consequences of infectious diseases*. Washington, DC ASM Press.

Fuentes, R., Pfütze, T., & Seck, P. (2006). A logistic analysis of diarrhea incidence and access to water and sanitation *Background paper for Human Development Report 2006*. New York: United Nations Development Programme.

Genthe, B., Strauss, N., Vundule, C., Maforah, F., & Seager, J. (1995). The effect of water supply, handling and usage on water quality in relation to health indices in a developing community in south africa. *Urban Health News*(26), 32-36.

Grabow, W.O.K., Taylor, M.B., Clay, C.G., & de Villiers, J.C. (2000). *Molecular detection of viruses in drinking water: Implications for safety and disinfection.* Paper presented at the Second Conference of the International Life Sciences Institute: The safety of water disinfection: balancing chemical and microbial risks, Radisson Deauville Resort, Miami Beach, FL.

Grantham-McGregor, S., Cheung, Y.B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. *Lancet, 369*(9555), 60-70. doi: 10.1016/s0140-6736(07)60032-4

Gujarati, D.N. (2003). Basic econometrics. 4th: New York: McGraw-Hill.

Hatting, J., Maree, G.A., Ashton, P.J., Leaner, J.J., Rascher, J., & Turton, A.R. (2007). Introduction to ecosystem governance: Focusing on africa. *Water Policy, 9*(2), 5-10.

Ihabi, A.N., Rohana, A.J., Wan Manan, W.M., Wan Suriati, W.N., Zalilah, M.S., & Rusli, A.M. (2013). Nutritional outcomes related to household food insecurity among mothers in rural malaysia. *Journal of Health, Population and Nutrition, 31*(4), 480-489.

Kebede, D., Soumbey-Alley, W., Asamoah-Odei, E., Lusamba-Dikassa, P., & Sambo, L. (2010). Progress on the health-related mdgs in the african region. *African Health Monitor, 10*, 10-17.

Khera, R., Jain, S., Lodha, R., & Ramakrishnan, S. (2014). Gender bias in child care and child health: Global patterns. *Archives of disease in childhood, 99*(4), 369-374.

Kimani-Murage, E.W., Holding, P.A., Fotso, J.C., Ezeh, A.C., Madise, N.J., Kahurani, E.N., & Zulu, E.M. (2011). Food security and nutritional outcomes among urban poor orphans in nairobi, kenya. *Journal of Urban Health 88*(2), S282-297. doi: 10.1007/s11524-010-9491-z

Kremer, M., Ahuja, A., & Zwane, A. (2010). Providing safe water: Evidence from randomized evaluations. Cambridge, Massachusetts: Harvard Environmental Economics Program.

Lansley, D. (2014). Rapid urbanisation, economic growth and the well-being of children. Monrovia, CA: World Vision International.

Levy, K. (2007). Environmental drivers of water quality and waterborne disease in the tropics with a particular focus on northern coastal ecuador (Vol. PhD Environmental Science, Policy and Management). Berkeley: University of California.

Lewin, S., Norman, R., Nannan, N., Thomas, E., Bradshaw, D., & South African comparative risk Assessment collaborating Group. (2007). Estimating the burden of disease attributable to unsafe water and lack of sanitation and hygiene in south africa in 2000. *South African Medical Journal, 97*(8), 755-762.

Luoto, J., Levine, D., & Albert, J. (2011). Information and persuasion: Achieving safe water behaviors in kenya. Santa Monica: Rand Labor and Population.

Mahendraker, A.G., Dutta, P.K., Urmil, A.C., & Moorthy, T.S. (1991). A study of medico social profile of under five children suffering from diarrhoeal diseases. *Indian Journal of Maternal and Child Health, 2*(4), 127-130.

Majuru, B., Michael Mokoena, M., Jagals, P., & Hunter, P.R. (2011). Health impact of small-community water supply reliability. *International Journal of Hygiene and Environmental Health, 214*(2), 162-166. doi: 10.1016/j.ijheh.2010.10.005

Mechenich, C., & Andrews, E. (1993). *Interpreting drinking water test results*. Madison: University of Wisconsin--Extension.

Mellor, J.E., Smith, J.A., Learmonth, G.P., Netshandama, V.O., & Dillingham, R.A. (2012). Modeling the complexities of water, hygiene, and health in limpopo province, south africa. *Environmental Science and Technology 46*(24), 13512-13520. doi: 10.1021/es3038966

Miguel, E., & Kremer, M. (2004). Worms: Identifying impacts on education and health in the presence of treatment externalities. *Econometrica, 72*(1), 159-217. doi: 10.1111/j.1468-0262.2004.00481.x

Molbak, K., Jensen, H., Ingholt, L., & Aaby, P. (1997). Risk factors for diarrheal disease incidence in early childhood: A community cohort study from guinea-bissau. *American Journal of Epidemiology, 146*(3), 273-282.

Mondal, N., Hossain, K., & Ali, K. (2009). Factors influencing infant and child mortality: A case study of rajshahi district, bangladesh. *Journal of Human Ecology, 26*(1), 31-39.

Mosley, W.H., & Chen, L.C. (1984). An analytical framework for the study of child survival in developing countries. *Population and development review, 10*(Supplement), 25-45.

Mott, L., Fore, D., Curtis, J., & Solomon, G. (1997). Children's special vulnerability to environmental risks *Our children at risk the five worst environmental threats to their health*. New York: National Resource Defense Council.

Muller. (2002). The national water and sanitation programme in south africa: Turning the 'right to water' into reality. Nairobi: Water and Sanitation Program-Africa Region

Mustard, J.F. (2010). Early brain development and human development In R. Tremblay, M. Boivin & R. Peters (Eds.), *Encyclopedia on early childhood development [online]*. Montreal, Quebec: Centre of Excellence for Early Childhood Development and Strategic Knowledge Cluster on Early Child Development.

Nannan, N., Dorrington, R., Laubscher, R., Zinyakatira, N., Prinsloo, M., Darikwa, T., . . . Bradshaw, D. (2012). Under-5 mortality statistics in south africa: Shedding some light on the trends and causes 1997-2007. Cape Town: South African Medical Research Council.

National Treasury. (2011). Local government budgets and expenditure review. Pretoria: National Treasury.

Nauges, C., & Strand, J. (2013). Water hauling and girls' school attendance: Some new evidence from ghana. Washington, DC: World Bank.

Niehaus, M.D., Moore, S.R., Patrick, P.D., Derr, L.L., Lorntz, B., Lima, A.A., & Guerrant, R.L. (2002). Early childhood diarrhea is associated with diminished cognitive function 4 to 7

years later in children in a northeast brazilian shantytown. *The American Journal of Tropical Medicine and Hygiene, 66*(5), 590-593.
North Carolina Institute of Medicine Task Force on Prevention. (2009). Prevention for the health of north carolina: Prevention action plan. Morrisville: North Carolina Institute of Medicine.
Obi, C., Onabolu, B., Momba, M., Igumbor, J., Ramalivahna, J., Bessong, P., . . . Mulaudzi, T. (2006). The interesting cross-paths of hiv/aids and water in southern africa with special reference to south africa. *Water SA, 32*(3), 323-343.
Obi, C.L., Potgieter, N., Bessong, P.O., & Matsaung, G. (2003). Scope of potential bacterial agents of diarrhoea and microbial assessment of quality of river water sources in rural venda communities in south africa. *Water Science and Technology, 47*(3), 59-64.
Paul, A., Doocy, S., Tappis, H., & Funna Evelyn, S. (2014). Preventing malnutrition in post-conflict, food insecure settings: A case study from south sudan. *PLOS Currents Disasters, 6*(1), 1-13. doi: 10.1371/currents.dis.54cd85fa3813b0471abc3ebef1038806
Prüss-Üstün, A., & Corvalan, C. (2007). How much disease burden can be prevented by environmental interventions? *Epidemiology, 18*(1), 167-178. doi: 10.1097/01.ede.0000239647.26389.80
Republic of South Africa. (1996). *The constitution of the republic of south africa*. Pretoria: Government printers.
Sanders, D., Reynolds, L., Eley, B., Kroon, M., Zar, H., Davies, M.-A., . . . Heerden, T.v. (2007). Western cape burden of disease project. Cape Town: Western Cape Department of Health.
SANS. (2011). 241-1 drinking water specification Pretoria: South African Bureau of Standards
Sauerborn, R., Berman, P., & Nougtara, A. (1996). Age bias, but no gender bias, in the intra-household resource allocation for health care in rural burkina faso. *Health Transition Review : the cultural, social, and behavioural determinants of health 6*(2), 131-145.
Schultz, T.P. (1984). Studying the impact of household economic and community variables on child mortality. *population and Development Review, 10*(Supplement), 215-235.
Shekar, M., Heaver, R., & Lee, Y.-K. (2006). *Repositioning nutrition as central to development: A strategy for large scale action*. Washington: World Bank.
Smith, K.R., Corvalán, C.F., & Kjellström, T. (1999). How much global ill health is attributable to environmental factors? *Epidemiology, 10*(5), 573-584.
Stats SA. (2006). General household survey 2006. Cape Town: Data First.
Stats SA. (2011). General household survey Cape Town: Data First.
Stats SA. (2011a). Water and sanitation 2002–2010, in-depth analysis of the general household survey data *GHS Series* (Vol. III). Pretoria: Statistics South Africa.
Stats SA. (2011b). General household survey 2011 metadata. Pretoria: Statistics South Africa.
Stats SA. (2013). Millenium development goals, country report 2013. Johannesburg Statistics South Africa.
UNAIDS. (2013). Unaids report on the global aids epidemic 2013 *Global Report* Geneva: UNAIDS.
UNCESCR. (2002). *General comment 15, the right to water* (U.N. Doc. E/C.12/2002/11). United Nations Committee on Economic, Social and Cultural Rights.
UNFPA, & IPEA. (2007). Mdg 4: Reduce child mortality *Potential contributions to the mdg agenda from the perspective of icpd: A reference guide to evidence for policy dialogue in the lac region*. Brasilia United Nations Population Fund.
UNICEF. (2009). Diarrhoea: Why children are still dying and what can be done New York: UNICEF and WHO.

UNICEF. (2011). Gender influences on child survival, health and nutrition: A narrative review. New York: UNICEF
UNICEF. (2012). *Pneumonia and diarrhoea: Tackling the deadliest diseases for the world's poorest children*. New York: UNICEF.
UNICEF. (2012a). *Committing to child survival: A promise renewed*. New York: UNICEF.
United Nations. (2008). The millennium development goals. New York: United Nations.
United Nations. (2010). *The human right to water and sanitation*. Paper presented at the U.N. Doc. A/64/L.63/Rev.1
Van Vuuren, L. (2013). Poor and angry – research grapples with reasons behind social protests. *Water Wheel, 12*(6), 14-16.
Vanderkooi, M. (2000). *Village medical manual: A layman's guide to health care in developing countries: Diagnosis and treatment* (Vol. 2). Pasadena: William Carey Library.
von Schirnding, Y.E., Yach, D., Blignault, R., & Mathews, C. (1991). Environmental determinants of acute respiratory symptoms and diarrhoea in young coloured children living in urban and peri-urban areas of south africa. *South African Medical Journal, 79*(8), 457-461.
Wang, X., & Hunter, P.R. (2010). A systematic review and meta-analysis of the association between self-reported diarrheal disease and distance from home to water source. *The American journal of tropical medicine and hygiene, 83*(3), 582-584.
Waters, E., Goldfield, S., & Hopkins, S. (2007). Indicators for child health, development and wellbeing; a systematic review of the literature and recommendations for population monitoring. Melbourne, Australia: Centre for community child health, Royal children's hospital.
WHO. (1997). *Guidelines for drinking-water quality* (2nd ed. Vol. 3). Geneva: World Health Organisation.
WHO. (1999). Removing obstacles to healthy development: Report on infectious diseases. Geneva: World Health Organization.
WHO. (2007). Children's environmental health. Retrieved 12 September, 2013, from http://www.who.int/ceh/en/
WHO. (2009). Early child development. Retrieved 14 March 2012, from http://www.who.int/mediacentre/factsheets/fs332/en/index.html
Wittenberg, D.F. (2012). Management guidelines for acute infective diarrhoea / gastroenteritis in infants. *South African Medical Journal, 102*(2), 104-107.
Woldemicael, G. (2001). Diarrhoeal morbidity among young children in eritrea: Environmental and socioeconomic determinants. *Journal of Health, Population and Nutrition, 19*(2), 83-90.
World Bank. (2008). *Environmental health and child survival - epidemiology, economics and experiences*. Washington: World Bank.
World Health Organization. (2002). The world health report: 2002: Reducing the risks, promoting healthy life.
Wright, J., Gundry, S., & Conroy, R. (2004). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. *Tropical Medicine & International Health, 9*(1), 106-117.
Ygberg, S., & Nilsson, A. (2012). The developing immune system - from foetus to toddler. *Acta Paediatrica, 101*(2), 120-127. doi: 10.1111/j.1651-2227.2011.02494.x

Appendices

Appendix 1: GHS 2006 and 2011 Questions

Access to water

2006

4.19	What is the household's main source of water? *Mark one code only*	Drinking	Other
	01 = Piped (tap) water in dwelling — *Go to Q 4.21*	☐ 01	☐ 01
	02 = Piped (tap) water on site or in yard — *Go to Q 4.21*	☐ 02	☐ 02
	03 = Borehole on site — *Go to Q 4.21*	☐ 03	☐ 03
	04 = Rain-water tank on site — *Go to Q 4.21*	☐ 04	☐ 04
	05 = Neighbour's Tap	☐ 05	☐ 05
	06 = Public/Communal tap	☐ 06	☐ 06
	07 = Water-carrier/Tanker	☐ 07	☐ 07
	08 = Borehole off site/communal	☐ 08	☐ 08
	09 = Flowing water/Stream/River	☐ 09	☐ 09
	10 = Stagnant water/Dam/Pool	☐ 10	☐ 10
	11 = Well	☐ 11	☐ 11
	12 = Spring	☐ 12	☐ 12
	13 = Other, *specify* …………………………………..	☐ 13	☐ 13

2010

3.12 What is the household's main source of drinking water?

01 = Piped (tap) water in dwelling/house → ***Go to Q3.14***
02 = Piped (tap) water in yard → ***Go to Q3.14***
03 = Borehole in yard → ***Go to Q3.14***
04 = Rain-water tank in yard → ***Go to Q3.14***
05 = Neighbour's tap
06 = Public/communal tap
07 = Water-carrier/tanker
08 = Borehole outside yard
09 = Flowing water/stream/river
10 = Stagnant water/dam/pool
11 = Well
12 = Spring
13 = Other (specify)

Households' main source of drinking water is supplied by a municipality

2006

4.23	Does this household have access to piped water from a local municipality?	
	1 = Yes	☐ 1
	2 = No → **Go to 4.30**	☐ 2

2010

3.16 Is your main source of drinking water supplied by a municipality?

1 = Yes		1
2 = No	→ ***Go to Q3.22***	2
3 = Do not know	→ ***Go to Q3.22***	3

Distance to water source

2006

4.20	How far is the water source for drinking from the dwelling, yard or site (200m is equal to two football fields)?	
	1 = Less than 200m	☐ 1
	2 = Between 201m – 500m	☐ 2
	3 = Between 501m – 1km	☐ 3
	4 = More than 1 km	☐ 4
	5 = Don't Know	☐ 5

2010

3.13a How far is the water source from the dwelling or yard (200m is equal to the length of two football/soccer fields)?

1 = Less than 200 metres	1
2 = 201 - 500 metres	2
3 = 501 - 1 kilometre	3
4 = More than 1 kilometre	4
5 = Do not know	5

Quality of municipally provided water

2006

		Yes	No
4.21	**Is the water from the main source of drinking water…..**		
	1 = Safe to drink?	☐ 1	☐ 2
	2 = Clear (have no colour / free of mud)?	☐ 1	☐ 2
	3 = Good in taste?	☐ 1	☐ 2
	4 = Free from bad smells?	☐ 1	☐ 2

2010

		Yes	No
3.14	**Is the water from the main source of drinking water before any treatment …..** *Read all the options*		
	1 = Safe to drink?	1	2
	2 = Clear (has no colour / free of mud)?	1	2
	3 = Good in taste?	1	2
	4 = Free from bad smells?	1	2

Need to treat water again

2006

4.22	**Do household members treat the water used for drinking?**	
	1 = Yes, always	☐ 1
	2 = Yes, sometimes	☐ 2
	3 = No, never	☐ 3

2010

3.15	**Do household members treat the water used for drinking?** *This may include boiling, adding chlorine or other chemicals, filtering.*	
	1 = Yes, always	1
	2 = Yes, sometimes	2
	3 = No, never	3

Interruptions

2006

4.27	**How often does the household have water interruptions in its piped water supply?**	
	1 = Daily	☐ 1
	2 = Weekly	☐ 2
	3 = Monthly	☐ 3
	4 = 6 monthly	☐ 4
	5 = Yearly	☐ 5
	6 = Almost never → ***Go to Q 4.30***	☐ 6

2010

3.19a	**Has your municipal water supply been interrupted at any time during the last 12 months?**	
	1 = Yes	1
	2 = No → ***Go to Q3.22***	2

Rate the quality of municipal water service

2006

4.24	**How do you rate the municipal water services you receive?**	
	1 = Good	☐ 1
	2 = Average	☐ 2
	3 = Poor	☐ 3

2010

3.17	*Ask if "Yes" in Q3.16* **How do you rate the municipal water services you receive?**	
	1 = Good	1
	2 = Average	2
	3 = Poor	3

Payment for water

2006

4.25	**Does the household pay for water?** 1 = Yes → ***Go to Q 4.27*** 2 = No → ***Go to Q 4.26***	☐ 1 ☐ 2

2010

3.18 Does the household pay for municipal water? *Include payment to a Water Board or Water Services Provider. If cost of water is included in a levy/rent paid to a housing complex/owner/landlord, the response should be "No".*

1 = Yes — 1

2 = No — 2

Incidence of diarrhoea among children (aged 5 years and younger) in the month preceding the survey

2006

1.19	**During the past month, did ...... suffer from any illnesses or injuries?** 1 = Yes 2 = No → ***Go to Q 1.28***	☐ 1 ☐ 2	
1.20	**What sort of illnesses or injuries did ...... suffer from? Did ...... suffer from ......**	Yes	No
	01 = Flu or acute respiratory tract infection	☐ 1	☐ 2
	02 = Diarrhoea	☐ 1	☐ 2
	03 = Severe trauma *(e.g. due to violence, motor vehicle accident, gunshot, assault, beating)*	☐ 1	☐ 2
	04 = TB or severe cough with blood	☐ 1	☐ 2
	05 = Abuse of alcohol or drugs	☐ 1	☐ 2
	06 = Depression or mental illness	☐ 1	☐ 2
	07 = Diabetes	☐ 1	☐ 2
	08 = High or low blood pressure	☐ 1	☐ 2
	09 = HIV/AIDS	☐ 1	☐ 2
	10 = Other sexually transmitted disease	☐ 1	☐ 2
	11 = Other illness or injury	☐ 1	☐ 2

2010

1.26a During the past month, did ...... suffer from any illnesses or injuries?

1 = Yes

2 = No → ***Go to Q1.28a***

3 = Do not know → ***Go to Q1.28a***

1.26b *If "Yes" in Q1.26a*

What sort of illnesses or injuries did ...... suffer from? Did ...... suffer from ......

Read all the options

01 = Flu or acute respiratory tract infection

02 = Diarrhoea

03 = TB or severe cough with blood

04 = Abuse of alcohol or drugs

05 = Depression or mental illness

06 = Diabetes

07 = High blood pressure/hypertension

08 = Sexually transmitted diseases

09 = Cancer

10 = Motor vehicle accident injuries

11 = Gunshot wounds

12 = Severe trauma *due to violence, assault, beating*

13 = Minor trauma (e.g. cuts, breaking arm)

14 = Other illness or injury (specify in box below)

15 = Do not know

Presence of biological mother

2006

1.4.a	**Is ......'s biological mother still alive?** 1 = YES 2 = NO 3 = DON'T KNOW → ***Go to Q1.5.a***	☐ 1 ☐ 2 ☐ 3
1.4.b	**Is ......'s biological mother part of this household?** 1 = YES 2 = NO → ***Go to Q1.5.a***	☐ 1 ☐ 2
1.4.c	**Which person is ......'s biological mother?** *Give person number*	

2010

1.4a Is ......'s biological mother still alive?
1 = Yes
2 = No → ***Go to Q1.5***
3 = Do not know → ***Go to Q1.5***

1.4b Is ......'s biological mother part of this household?
1 = Yes
2 = No → ***Go to Q1.5***

Education level

2011

1.6 What is the highest level of education that ...... has successfully completed?
Diplomas or certificates must be of six months plus study duration full-time (or equivalent) to be included

98 = No schooling
00 = Grade R/0
01 = Grade 1/ Sub A/Class 1
02 = Grade 2 / Sub B/Class 2
03 = Grade 3/Standard 1/ ABET 1(Kha Ri Gude, Sanli)
04 = Grade 4/ Standard 2
05 = Grade 5/ Standard 3/ ABET 2
06 = Grade 6/Standard 4
07 = Grade 7/Standard 5/ ABET 3
08 = Grade 8/Standard 6/Form 1
09 = Grade 9/Standard 7/Form 2/ ABET 4
10 = Grade 10/ Standard 8/ Form 3
11 = Grade 11/ Standard 9/ Form 4
12 = Grade 12/Standard 10/Form 5/Matric (No Exemption)
13 = Grade 12/Standard 10/Form 5/Matric (Exemption *)
14 = NTC 1/ N1/NC (V) Level 2
15 = NTC 2/ N2/ NC (V) Level 3
16 = NTC 3/ N3/NC (V)/Level 4
17 = N4/NTC 4
18 = N5/NTC 5
19 = N6/NTC 6
20 = Certificate with less than Grade 12/Std 10
21 = Diploma with less than Grade 12/Std 10
22 = Certificate with Grade 12/Std 10
23 = Diploma with Grade 12/Std 10
24 = Higher Diploma (Technikon/University of Technology)
25 = Post Higher Diploma (Technikon/University of Technology Masters, Doctoral)
26 = Bachelors Degree
27 = Bachelors Degree and post-graduate diploma
28 = Honours Degree
29 = Higher degree (Masters, Doctorate)
30 = Other (specify in the box below)
31 = Do not know

Child Nutrition

2011

3.52 In the past 12 months, did any child (17 years or younger) in this household go hungry because there wasn't enough food?

1 = Never
2 = Seldom
3 = Sometimes
4 = Often
5 = Always
6 = Not applicable (No children in household)

Household Expenditure

2011

4.14 What was the total household expenditure in the last month?
Include money spent on food, clothing, transport, rent and rates, alcohol and tobacco, school fees, entertainment and any other expenses.

01 = R0
02 = R1 - R199
03 = R200 - R399
04 = R400 - R799
05 = R800 - R1 199
06 = R1 200 - R1 799
07 = R1 800 - R2 499
08 = R2 500 - R4 999
09 = R5 000 - R9 999
10 = 10 000 or more
11 = Do not know
12 = Refuse

Access to toilet facilities

2006

4.30 What type of toilet facility is available for this household? *Main type*

Toilet facility	In dwelling	On site	Off site
1 = Flush toilet with offsite disposal	☐ 11	☐ 12	☐ 13
2 = Flush toilet with on site disposal (septic tank)	☐ 21	☐ 22	☐ 23
3 = Chemical toilet		☐ 32	☐ 33
4 = Pit latrine with ventilation pipe		☐ 42	☐ 43
5 = Pit latrine without ventilation pipe		☐ 52	☐ 53
6 = Bucket toilet		☐ 62	☐ 63
7 = None → ***Go to Q 4.31***			☐ 73

2011

3.22 What type of toilet facility is used by this household?

1 = Flush toilet connected to a public sewerage system
2 = Flush toilet connected to a septic tank → ***Go to Q3.24***
3 = Chemical toilet → ***Go to Q3.24***
4 = Pit latrine/toilet with ventilation pipe → ***Go to Q3.24***
5 = Pit latrine/toilet without ventilation pipe → ***Go to Q3.24***
6 = Bucket toilet → ***Go to Q3.24***
7 = None → ***Go to Q3.27***
8 = Other (specify) → ***Go to Q3.27***

Appendix 2: Additional Tables

Table A2-1: Probit estimation of the probability if diarrhoeal disease in children under the age of five, initial models

	Model i: Basic		Model ii: Basic + income		Model iii: Basic + household variables		Model iii: Full model	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Gender(Male)	0.03	0.10	0.03	0.10	0.02	0.10	0.02	0.10
Age	-0.10***	0.03	-0.10***	0.03	-0.10***	0.03	-0.10***	0.03
Western Cape	0.04	0.16	0.04	0.16	0.02	0.16	0.03	0.16
Eastern Cape	0.00	0.18	-0.03	0.19	0.00	0.18	-0.02	0.18
Free State	-0.20	0.18	-0.22	0.19	-0.21	0.19	-0.22	0.19
KwaZulu-Natal	-0.55**	0.22	-0.58***	0.22	-0.55**	0.22	-0.58***	0.22
North West	0.08	0.20	0.07	0.20	0.07	0.20	0.06	0.20
Mpumalanga	-0.06	0.18	-0.08	0.18	-0.07	0.19	-0.09	0.19
Limpopo	0.04	0.20	-0.01	0.20	0.02	0.19	-0.03	0.19
Urban informal	0.11	0.20	0.08	0.20	0.09	0.20	0.08	0.20
Tribal area	-0.29*	0.17	-0.31*	0.17	-0.26	0.17	-0.27	0.17
Rural	-0.65*	0.35	-0.69*	0.35	-0.64*	0.36	-0.67*	0.36
White	-0.45	0.34	-0.34	0.34	-0.49	0.34	-0.42	0.34
Coloured	-0.06	0.15	-0.01	0.15	-0.03	0.15	0.01	0.15
Indian	-0.02	0.37	0.09	0.37	-0.06	0.36	0.02	0.36
Household size	-	-	-	-	-0.02	0.03	-0.02	0.03
Age of household head	-	-	-	-	0.00	0.00	0.00	0.00
Male household head	-	-	-	-	-0.10	0.10	-0.07	0.10
Household income less than R1799	-	-	0.24**	0.10	-	-	0.23**	0.10
Highest Adult female education in household: Primary	-	-	-	-	-0.05	0.13	-0.07	0.14
Highest Adult female education in household: Secondary	-	-	-	-	-0.12	0.15	-0.11	0.14
Highest Adult female education in household: Tertiary	-	-	-	-	-0.05	0.15	0.04	0.14
Flush toilet	-	-	-	-	-	-	-	-
Piped in the house/on site	-0.05	0.19	-0.02	0.18	-0.04	0.16	-0.01	0.16
Treatment of water	-0.66***	0.25	-0.65***	0.25	-0.65	0.25	-0.66	0.25
Turbidity - Clear	-0.22	0.16	-0.21	0.16	-0.22***	0.16	-0.21***	0.16
Constant	-1.71	0.27	-1.86	0.24	-1.24	0.35	-1.47	0.32
F Statistic	2.34		2.80		2.53		2.69	
Unweighted sample size	9278		9201		9267		9190	

Source: Own calculations using GHS 2011 data (Stats SA, 2011)

Table A2-2: Pairwise correlation –Quality variables

	Safe	Clear	Taste	Smell
Safe	1			
Clear	0.8045	1		
Taste	0.7379	0.7607	1	
Smell	0.7408	0.7458	0.7237	1

Source: Own calculations using GHS 2011 data (Stats SA, 2011)

Table A2-3: Pairwise correlation – On-site piped water and access to a flush toilet.

	Piped water on-site	Flush toilet
Piped water on-site	1	
Flush toilet	0.6537	1

Source: Own calculations using GHS 2011 data (Stats SA, 2011)