The association between acute childhood diarrhoea and diarrhoeagenic *E.coli* present in contaminated soil in informal settlements in Durban

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Preshod Sewnand Ramlal

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Supervisor: Ms E.J.Kistnasamy: _____ Date: _____

Co-supervisor: Professor A.O.Olaniran:_____ Date _____

ABSTRACT

In South Africa, under-five childhood morbidity and mortality rates have increased due to diarrhoea with acute diarrhoea posing a major public health threat especially, in informal settlements. Therefore this study sought to, a) investigate community knowledge, attitudes, behaviour and practices (KABP) regarding domestic waste and childhood diarrhoeal management, b) to enumerate and identify diarrhoeagenic *E.coli* species from soil samples extracted from open waste dump sites and c) to investigate any association(s) with diarrhoeagenic *E.coli* and potential risk of contracting diarrhoea.

This two-phased cross-sectional study in six informal settlements in the greater Durban area constituted, respectively, of the administering of questionnaires to 360 primary caregivers and; sampling the prevalence of diarrhoeagenic *E.coli* (DEC) in waste dumps using quantitative polymerase chain reaction methodologies. Relationships between socio-demographic and educational status to determine potential household risk factors towards under-five diarrhoea prevalence were assessed.

The KABP results identified domestic waste and greywater disposal, mother and child method of sanitation, personal and domestic hygiene practices and mechanical vectors as significant contributory risk factors. Of concern is that more than 80% of under-five children played in or near faecally-contaminated waste dump sites. The recovery of four DEC pathotypes including enterohaemorrhagic *E.coli*, enteropathogenic *E.coli*, enterotoxigenic *E.coli* and enteroaggregative *E.coli* suggest that its persistence in waste-dump soil has the ability to cause under-five diarrhoea in both sporadic and endemic settings.

This commonly transmitted hand-to-mouth illness will necessitate and place huge demands on the primary catalysts of change i.e. local governmental role players and caregivers. These change agents have to ensure highly consistent levels of domestic and personal hygiene and implement feasible reduction strategies to waste-dump exposure of diarrhoeal-causing pathogens, particularly among under-five children living in Durban's informal settlements.

DECLARATION

The author hereby declares the content of this research dissertation is the author's own unaided original work, except where specific indication is given to the contrary (by reference). This work has not been previously submitted to the Durban University of Technology (DUT) or any other University.

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P.S Ramlal (Student number: 19601850)

B.Tech: Environmental Health (*Cum Laude*) (DUT 2004)

Honours of Administration: Public Administration (*Cum Laude*) (UNISA 2012)

Date:**2015**

Dedicated to:

My God, Dear Swami (SSSB) ...without your

Love nothing is possible...

My extremely helpful and loving wife Naina,

supportive mother,

Masha & Merlee,

My 2 super heroes: Tusshar & Abhay

&

In loving memory of my brother

DION (1978-2014)

and my younger brother, Pratish

...and most of all to a beautiful human being, my friend, confidante, lecturer, mentor, a kind-spirited soul and esteemed academic,...who has been so much more than a supervisor:

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who's unflinching support and belief in me from day 1 made this possible...

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ABBREVIATION/ACCRONYM	DEFINITION/LONG FORM
AIDS	Acquired Immune Deficiency Syndrome
CHW's	Community health workers
DAEC	Diffusely Adherent *E.coli*
EMA	eThekwini Municipal Area
DEC	Diarrhoeagenic *E.coli*
DSW	Durban Solid Waste
DWM	Domestic waste management
EAEC	Enteroaggregative *E.coli*
E.coli	*Escherichia coli*
EHEC	Enterohaemorrhagic *E.coli*
EIEC	Enteroinvasive *E.coli*
EMA	eThekwini Metropolitan Area
EPEC	Enteropathogenic *E.coli*
ETEC	Enterotoxigenic *E.coli*
HDA	Housing Development Agency
HIV	Human Immuno-deficiency Virus
IMViC	Indole, Methyl-red, Voges-proskauer
KABP	Knowledge Attitudes Behaviour & Practices

LA21	Local Agenda 21
MDG	Millennium Development Goals
MR	Methyl-Red
NMEC	Neonatal Meningitis *E.coli*
ORS	Oral Rehydration Solution
PCR	Polymerase Chain Reaction
PHC	Primary Health Care
SPSS	Statistical Package for Social Sciences
TSI	Triple Sugar Iron
UKZN	University of KwaZulu-Natal
UPEC	Uropathogenic *E.coli*
UTI	Urinary Tract Infections
VP	Voges-Proskauer
WHO	World Health Organization

CHAPTER 1

1.1 INTRODUCTION

Durban, the third most populous city in South Africa, is managed by the local government structure known as the eThekwini Municipality. Located on the east coast, it is the largest city in the province of Kwa-Zulu Natal (Marx and Charlton 2003: 3). It is estimated that 18% of the habitable land is occupied by formal households, 5% by informal households located in rural areas and approximately 10% of informal settlements, as shown in Figure 1.1 (eThekwini Municipality 2013: 20), are located on the urban fringes of the Durban city centre.

Durban having the largest free standing informal settlements in South Africa, is also experiencing increased urbanization through a rapid development of these settlements (eThekwini Municipality 2013: 24). In an email communication on 03 October 2014, Senior Manager of the eThekwini Municipality Human Settlements Unit, F. Seedat indicated that approximately 253 000 households were resident in informal settlements. Additionally, there were 134 settlements that were upgraded and 253 and 115 settlements, respectively, were earmarked for future upgrade and, for relocation.

According to P.S. Dlamini (Environmental Health Officer of the eThekwini City Health Unit), when interviewed on 17 May 2013, 11 informal settlements are situated within an 8 km radius to the south and north-west fringes of the Durban city centre. These informal settlements are burdened with many environmental risk factors including poorly constructed dwellings, inadequate water supply points and minimal sanitation services. However, unsatisfactory or inefficient domestic waste management (DWM) is often not a priority or considered of major public health significance. The main DWM problem is the accumulation of domestic waste and greywater (wastewater) disposal into

indiscriminate and unmanaged open waste dump sites, which may have the potential to contribute to significant environmental and human health risks.

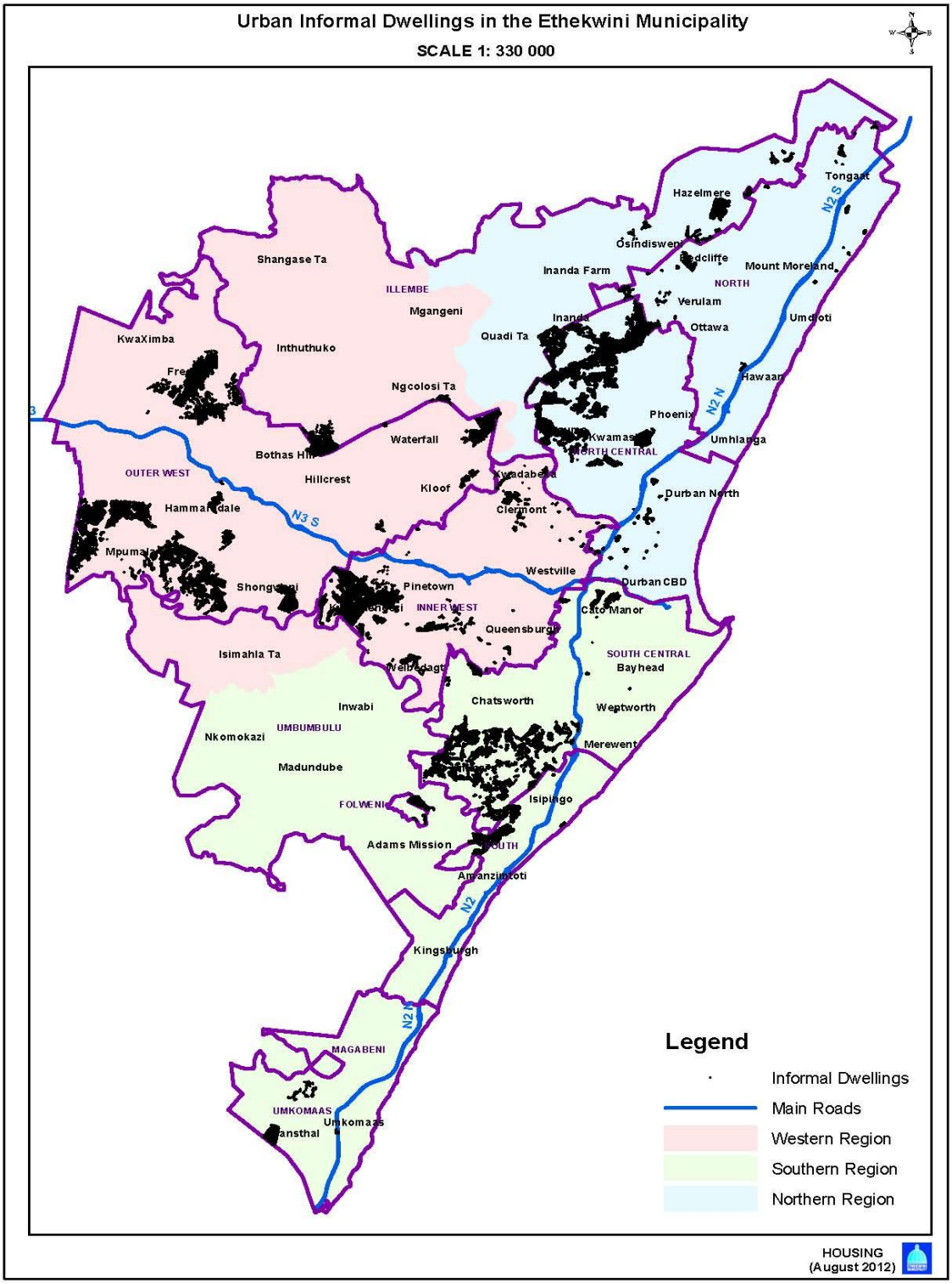

Figure 1.1: Spatial distribution of informal settlement dwellings (Seedat, 2014).

It is widely documented that a host of infectious microbiological pathogens are present in soil, water, air, greywater, wastewater, fresh rainwater, surface runoff and decomposing waste and a combination of these media within open waste dumps inevitably result in their survival, growth and proliferation (Armitage *et al.* 2009: 2342; Cabral 2010: 3657; Brooks *et al*. 2011: 2009; Baumgardner 2012: 735; Kaushik and Balasubramanian 2012: 131; Sidhu *et al*. 2012: 6652). Wastes disposed in landfill sites or dumps become part of the prevailing hydrological system and eventually form leachate (Pedley *et al.* 2006: 49). However, open waste dumps caused as a result of unplanned, indiscriminate dumping, can be a fertile source of pathogens in soil because these dump sites do not have a leachate collection system.

According to Awisan *et al*. (2011: 27) indiscriminate waste dumping promoted growth and multiplication of harmful and opportunistic bacterial microorganisms which posed a huge risk to public health. Therefore, the impact of waste dumping may significantly increase community-acquired infections like diarrhoea, as noted by an examination of soil from waste dumps where a number of disease causing bacterial pathogens, including *Escherichia coli* (*E.coli*) were enumerated. This may also compound communicable disease morbidity and mortality particularly, among an already vulnerable population group. Indiscriminately dumped waste also results in a range of cumulative problems such as the harbouring of vectors, namely flies, cockroaches and rodents which are known to carry and transmit pathogens to humans and have been linked to a number of health risks and diseases including diarrhoea (Osumanu, 2007: 66; Copps, 2012: 5).

Anecdotal evidence collected in a 2011 observational demographic survey and risk profiling of informal settlements by the eThekwini Municipality Health Department indicated that residents disposed of greywater into nearby dumps, common sites or into poorly constructed make-shift drains immediately outside their shacks. Additionally, P.S. Dlamini confirmed that some slum dwellers occasionally defecated near waste dumps or into plastic

bags, often referred to as ‘plastic toilets’ which were subsequently discarded directly into these waste dumps thereby causing an aesthetically unpleasant, offensive and odious environment (2013, pers.comm.12 May).

Wild and domestic animals including rats, mice, mongoose, poultry, cats and dogs were often found foraging and their droppings scattered within these waste disposal sites. Flies, maggots, rodents, cockroaches, crickets and mosquito breeding was a typical feature of these open putrescible waste dumps. In some instances, broken or damaged pipes from ablution blocks caused sewerage to flow into various areas within the settlements including seepage into waste dumps.

An intensive literature search has revealed that to date, no published studies have been performed in informal settlements in Durban that assessed the impacts of bacterial pathogens in waste dumps as a potential etiological agent of childhood diarrhoea. While the majority of scientific studies have investigated pathogens in terms of waterborne and foodborne reservoirs and transmission pathways, this study aims to investigate disease-causing bacterial pathogens as a “wasteborne” source of community illness.

1.2 BACKGROUND OF STUDY AREA

The formation and spread of unpermitted open waste dumps in Durban’s informal settlements is becoming an increasingly serious public health concern. These domestic waste dumps typically consist of a mixture of wastes, namely, human faeces, food wastes, animal and bird droppings, soiled nappies, plastics (broken buckets, juice and milk bottles), plastic and paper bags, cardboard, dry leaves, styrofoam, tin cans, paper, wood, broken glass bottles, medicine bottles, batteries, items of clothes and materials, garden refuse, greywater disposal and seasonal surface storm water runoff (Plate 1.1: Jadhu Place informal settlement in Durban).

Plate 1.1: A typical waste dump: Jadhu Place informal settlement (November 2012)

A retrospective review of clinical data obtained from three primary health care (PHC) clinics of the eThekwini Municipality Health Unit revealed a high number of acute diarrhoeal cases among children under-five years of age as indicated in Table 1.1 below:

Table1.1 : Diarrhoeal Cases Recorded: 01 January 2010 – 28 February 2014 (eThekwini Health Unit, 2014)

Name of Clinic	Name of Informal settlement where patients (children) reside	Age Group: < 5 years of age
Overport	Puntans Hill Jadhu Place	71
Sydenham	Burnwood Lacey Road	295
Clare Estate	Kennedy Road Foreman Road	449
	Sub-Total	**815**

In a telephonic conversation on 22 September 2014, former PHC Manager, N. Hlope (South 4, eThekwini Health Sub-District Office) confirmed that the abovementioned acute childhood diarrhoeal statistics reported between 2010–2014 was significantly higher among children under five years and, a cause for serious concern which warrants further epidemiological investigation. Stool samples are not taken from children aged 0–5 years old that present with diarrhoeal symptoms at eThekwini Municipality's PHC clinics but are instead referred to local provincial hospitals for stool analysis. However, it is unknown whether such analysis is being conducted.

Limited resources advocated that it was more feasible to conduct a focussed study in a designated area among children less than 5 years old that showed a high risk and prevalence of acute diarrhoea. As a result of the reported cases (Table 1.1) of acute childhood diarrhoea, the Jadhu Place, Puntans Hill, Burnwood, Lacey Road, Foreman Road and Kennedy Road informal settlements, which all lie in close proximity to each other, were chosen as the study population.

1.3 OBJECTIVES OF STUDY

1. To investigate community knowledge, attitudes, behaviour and practices (KABP) regarding domestic waste and childhood diarrhoeal management.

2. To enumerate and identify diarrhoeagenic *E*.coli species from soil samples extracted from open waste dump sites.

3. To investigate any association(s) with diarrhoeagenic *E*.coli and potential risk of contracting diarrhoea.

1.4 RATIONALE FOR STUDY

Due to a lack of recreational facilities and open spaces within these informal settlements, children often used these unhealthy and unsafe areas as their only playgrounds. A lack of demographic and socio-economic data and an inadequate understanding of behavioural and environmental risk factors that may contribute to the prevalence of childhood diarrhoea within the selected locations, necessitated a community survey.

A two-phased approach was used to achieve the study objectives and involved the following:

- ***PHASE 1***: The administration of a validated questionnaire to mothers and/or primary caregivers of children under-five residing within the six selected settlements to investigate how KABP related to domestic waste management and how other determinants may contribute to the prevalence of childhood diarrhoea.

- ***PHASE 2***: The use of standard microbiological laboratory techniques for isolating, enumerating, identifying and characterizing diarrhoeagenic *E.coli* (DEC) in waste dump site soil. Soil samples were taken from waste dumps within the six selected settlements (Figure 1.2) to assess whether DEC present in indiscriminate open waste dumps could be a contributory reservoir and transmission pathway of childhood diarrhoea.

Figure 1.2: Aerial map of the greater Durban area indicating the 6 selected informal settlements.

1.5 HYPOTHESES OF STUDY

It is hypothesized that:

- The caregiver's knowledge, attitudes, behaviour and practices regarding domestic waste and childhood diarrhoeal management is greatly influenced by their educational status.
- diarrhoeagenic *E.coli* are present in contaminated soil within open waste dumps found in the six study areas.
- monitoring the microbiological quality of these open waste dumps will assist in evaluating the risks associated with specific DEC strains particularly among children that play in and near these waste sites.

The next chapter will review literature relating to each objective.

CHAPTER 2

LITERATURE REVIEW

2.1 SITUATIONAL ANALYSIS: POPULATION AND INFORMAL SETTLEMENTS IN ETHEKWINI MUNICIPALITY (DURBAN)

2.1.1 Population trends in the eThekwini Municipality

The population of eThekwini has, from 2001-2011, increased at an annual rate of 1.13% per annum to approximately 3.44 million citizens (eThekwini Municipality 2013: 20). The major force that drives population growth is migration which impacts on employment, infrastructural and social services and basic housing needs including, household service backlogs.

According to eThekwini Municipality (2013: 21), the province of KwaZulu Natal has the most migrants who reside mainly in eThekwini. The highest number of migrants (39 500) originated from outside South Africa's borders, with the next influx from Eastern Cape (38 500) followed by Gauteng (24 300). A vast majority of these migrants (15% of foreign nationals and 35% of Eastern Cape migrants) took up residence in informal settlements throughout the eThekwini Municipal Area (EMA).

2.1.2 Informal settlements in Durban

Informal settlements are characterized by shack dwellings that are usually constructed with corrugated iron, plastic, timber and metal sheeting. The internal floor areas of households are typically earth covered by linoleum or carpeting. Depending on the existence period, geographic location or rate of upgrade of the informal settlement, the sanitation system normally constitutes a combination of informal pit latrines or a purpose-designed communal flush

toilet systems connected to formal sewerage infrastructure and reticulated water supplied through communal taps (Marx and Charlton 2003: 5).

According to the UN-HABITAT report (2009: 5), informal settlements worldwide are characterized by single dwellings that accommodate five or more people and which is also used for communal cooking, sleeping and other domestic activities. Furthermore, it defines overcrowding in these settlements as households in excess of three occupants per room.

In the mid-1970s, informal settlements mushroomed due to apartheid policies and severe droughts in rural areas which started an influx of Africans seeking residence near urban areas across KwaZulu Natal. In Durban, particularly in the 1980s-1990s, rapid urbanization was characterized by land invasions sited often within Indian suburbs. This continual rural-urban migration resulted in the establishment and growth of hundreds of peri-urban informal settlements across the EMA (Marx and Charlton 2003: 6; eThekwini Municipality 2011: 6). The six selected settlements chosen for the study as indicated in Plate 2.1 are examples of informal settlements that have developed in former Indian areas in the greater Durban area.

Plate 2.1: Snapshot of the 6 selected informal settlements located in Durban

Informal settlements are known by many names in various regions around the world (Unger and Riley 2007: 1563). Defining these settlements may also vary from place to place within a country and therefore for the purposes of the present study, a definition that is applicable to South Africa and in particular Durban will be discussed.

2.2 DEFINITION OF INFORMAL SETTLEMENTS

In South Africa, informal settlements are typically characterized by densely clustered dwellings, usually >200 households per hectare, are illegal and have inappropriate topography plus geographic locations (Ashipala and Armitage 2011: 1781; eThekwini Municipality 2011: 70). The above characteristics was evidenced in the six study areas which lacked adequate drainage and sanitation frequently resulting in extremely polluted environments inclusive of a mixture of stormwater, sewage, greywater, household waste and excreta. Given the negative connotations associated with informal settlements, health and quality of life for these residents will be inextricably linked to the environment and development within these communities.

2.3 ENVIRONMENT, HEALTH AND DEVELOPMENT IN SOUTH AFRICA

2.3.1 Local Agenda 21

In the South African democratic era, Local Agenda 21 (LA21) recognizes the link between health and development including where unplanned informal housing perpetuates poverty and decreases resources (Patel 2014: 170). This ever increasing urban population is often burdened with environmental health risks and challenges (de Wet, Mathee and Barnes 2001: 78).

South Africa as a signatory to LA21, is cognisant of the critical need for integrated governmental action with special focus on policy implementation in actions directed at reducing environmental health threats and risks to citizens and their environments. Durban became the first South African city to accept LA21 with the eThekwini Municipality subsequently initiating a bottom-up community participation approach to tackle pressing local, cultural, environmental and social problems within all communities including informal settlements. The outcomes of these community workshops were drafted into the city's integrated development plan (Roberts and Diederichs 2002: 189; eThekwini Municipality 2013: 76; van Niekerk 2014: 83).

2.3.2 Traditional and Modern Hazards

Durban's domestic waste disposal and management in informal settlements has changed from a traditional threat to modern day environmental health hazards due mainly to contaminants changing and an increase in exposure and disease transmission among human populations. These hazards through waste, soil, water and airborne exposure can primarily impact the vulnerable populations in informal settlements (de Wet, Mathee and Barnes 2001: 78; Nweke and Sanders 2009: 867; Chopra and Kanji 2011: 463). South Africa's efforts in addressing poor living and socio-economic conditions, inequity,

inequality and poverty whilst ensuring environmental sustainability among its people has led to the country adopting eight Millennium Development Goals (MDGs).

2.3.3 Millennium Development Goals

The 2 core MDGs explored in this study included reducing child mortality and combatting diseases such as childhood diarrhoea (Groenewald 2011: 642). The main MDG's outcome was for all member states to achieve these listed goals by 2015. However, South Africa showed a reversal in attainment of these goals, particularly in reducing under-5 mortality rates by 2015 (Nsibande *et al*. 2013: 2). In South Africa, the target of under-five mortality was set at 20 deaths per thousand live births by end 2015 (Statistics South Africa 2013: 76), and since insufficient data was available, it is uncertain whether the country is likely to meet this target. It is also notable and alarming that deaths in the under-five age group in this country is caused by a preventable illness namely, childhood diarrhoea.

Hence, it is hoped that this study will assist with preventing or reducing childhood diarrhoea incidence within informal settlements. Destitute families, particularly mothers and children under-five are at escalated risk of morbidity and mortality as their living conditions predispose them to many challenges including timeous access to quality health care and treatment with the result that poor children have four times the risk of dying than their more affluent counterparts (Bradshaw *et al*. 2008: 1302). The next section will therefore describe the epidemiology of childhood diarrhoea in order to gain an understanding of its impact worldwide.

2.4 EPIDEMIOLOGY OF CHILDHOOD DIARRHOEA

Malnourished children who have impaired immunity and live in socio-economically impoverished localities like informal settlements will have a greater frequency and severity of diarrhoea with a higher mortality rate compared with their economically stable counterparts living in more developed areas (O'Ryan, Prado and Pickering 2005: 125; WHO 2013: 1). Diarrhoea, a serious public health challenge, is both preventable and treatable, yet it is listed globally as the second most frequent cause of child mortality. Acute diarrhoea among children under-five remains a significant cause of morbidity and mortality worldwide with approximately 2.4 billion episodes and 3-5 million deaths occurring annually (Kosek, Bern and Guerrant 2003: 197; Vargas *et al.* 2004: 536; Sanchez and Holmgren 2005: 388; Gupta *et al*. 2015: 23). According to Oketcho *et al.* (2012: 81) and Unger (2013: 801), childhood diarrhoea occurs most frequently in impoverished informal settlements characterized by squalid conditions, poor environmental sanitation and hygiene, overcrowding, inadequate water supplies, malnutrition and poverty and poor overall health and nutritional status among children.

It is of serious concern that more 80 percent of children living across Africa die every year from diarrhoea and 50% of these deaths are among children under-five (UN-HABITAT 2009: 5). In South Africa, diarrhoea is one of the leading causes of childhood morbidity and mortality, the second most common health problem treated in outpatient clinics and the third leading cause of death in the country (Bradshaw, Bourne and Nannan 2003: 3; Coetzer 2013: 5). Chola *et al*. (2015: 394) indicated that in 2010, diarrhoea was responsible for over 9000 under-five deaths and therefore poses a life-threatening risk to children and particularly among those that live in impoverished localities, similar to the chosen settlements in this study.

The report, Statistics South Africa (2010: 12) indicated that diarrhoeal incidence among children aged under-5 in South Africa fluctuated for the period 2001-2009. Table 2.1 depicts the breakdown in terms of provincial data with KwaZulu Natal having the highest incidence of diarrhoea from 2002–2009.

Table 2.1: Incidence of diarrhoea among children aged under-5years, by province, 2001 – 2009 (District Health Information System, Department of Health as cited by Statistics South Africa 2010)

	Year								
Province	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Western Cape	83.2	89.0	76.4	89.9	90.4	104.7	117.0	141.2	140.0
Eastern Cape	142.3	104.3	106.6	86.9	92.2	87.5	84.8	116.3	108.8
Northern Cape	229.2	151.2	156.3	161.1	166.9	191.7	171.7	168.0	160.7
Free State	78.1	72.3	82.0	78.7	79.4	76.3	71.5	83.0	69.6
KwaZulu Natal	206.2	191.5	197.3	212.7	191.1	210.7	206.8	203.6	204.4
North West	213.6	156.2	129.5	119.0	115.6	118.2	114.2	116.3	110.8
Gauteng	0.9	0.9	10.7	38.0	41.7	63.1	58.9	62.5	61.1
Mpumalanga	129.8	123.5	83.0	114.0	119.3	108.7	99.0	97.1	81.9
Limpopo	210.0	163.8	152.0	164.5	166.7	196.5	193.1	203.7	203.7

In 2013-2014, KwaZulu Natal recorded 15 cases per 1000 children with diarrhoea which was slightly more than the country's average of 14.1. The case fatality rate was not different in metro and non-metro areas of the province which showed 3.3 children/1000 in this age category dying from this preventable illness compared to the national average of 3.9 (Massyn *et al*. 2014: 144). According to eThekwini Municipality (2013: 37) and Nsibande *et al*. (2013: 2) South Africa is among a few countries where childhood mortality rates have increased due to diarrhoea thus clearly impacting on children by decreasing their life expectancy.

2.4.1 Definition of childhood diarrhoea

Smith (2013: 8) and Terblanche (2010: 28) explained that gastroenteritis in children, caused by bacterial, viral and parasitic pathogens is an acute syndrome characterized by inflammation in the child's gastrointestinal tract which results in sudden onset of diarrhoea. Although gastroenteritis and diarrhoea is commonly used interchangeably, the present study will refer to this childhood illness as diarrhoea. According to McGee (2009: 34) age and diet are key factors affecting the frequency, consistency, colour and content of stools in children with diarrhoea and a sudden, acute episode with or without blood or mucus warrants urgent medical and further clinical evaluation.

The World Health Organization (WHO 2013: 1) defines diarrhoea as the discharge of three or more loose or liquid stools per day, or more frequently than is normal for the child. However, Ongunlesi (2010: 2) cautioned that even a single explosive watery stool or unusually frequent but formed stools may be abnormal and must not be ignored, although such do not conform with the standard definition of diarrhoea.

Ongunlesi (2010: 4) further explained that breastfed new born babies and young infants' frequent passage of loose stools may be completely normal due to the effect of the gastro-colic reflex, and therefore it is extremely vital to pay attention to what the mother of an infant considers abnormal. Hence it is important to understand how best to eliminate and/or mitigate against potential risks of diarrhoea in disadvantaged communities particularly as the condition may not be easily and correctly identified or diagnosed which could rapidly lead to fatal consequences in children.

Armon *et al*. (2001: 132) and Coetzer (2013: 5) noted that clinical symptoms in children vary significantly and are dependent on the etiological agent, duration, severity of the diarrhoea, on the area of bowel affected, and on the

child's overall general health. The two most significant consequential implications of diarrhoea are dehydration and malnutrition, which occurs faster in infants and young children.

Childhood diarrhoea is classified into three major types including acute watery, persistent and chronic diarrhoea (McGee 2007: 26; Ongunlesi 2010: 7; Frank-Briggs 2012: 93). In this study setting, the most prevalent form of diarrhoea experienced among children under-five is acute which is characterized by a sudden passage of abnormally frequent, watery stools and may include dehydration, vomiting, pain, weakness and fever as related symptoms. In most cases, episodes usually last less than fourteen days depending on the causative agent of this childhood illness.

2.4.2 Causative agents of childhood diarrhoea

Both infectious and non-infectious agents may induce diarrhoea in children. Cooke (2010: 42), Ogunlesi (2010: 43), Kaiser and Surawicz (2012: 563) and Smith (2013: 8) indicated that the vast majority of cases of childhood diarrhoea in the developing world are infective and these include primarily bacterial, viral and parasitic infections. These three groups of pathogens may exist independently or in combination.

Many studies have identified food intolerances, reaction to medicines and antibiotics, intestinal diseases and functional bowel disorders as non-infectious causes of childhood diarrhoea (De Villiers 2008: 44; Labuschagne and Lombard 2009: 496; Alam and Mushtaq 2009: 491; Juckett and Trivedi 2011: 1121). This study excluded children under-five that experienced diarrhoea caused by these medically diagnosed conditions. Whilst childhood diarrhoea may be caused by metabolic deficiencies, organic disturbance or chemical irritation, this study investigated bacterial infection, specifically caused by DEC harboured in waste dumps as potential etiological agents.

2.4.3 Transmission routes of childhood diarrhoea

The easiest transmission route for the pathogen is through faeces excretion into the environment and possible ingestion by a new child host (route a) as illustrated in Figure 2.1. The second option is related to the pathogen's growth and survival in the environment, thereby increasing the probability of exposure and subsequent inhabitation within a new child host (route b). A third method is for the pathogenic agent to be discharged in faeces of a human host, proliferate or not in the environment, and subsequently be ingested and colonized in a domestic or wild animal, which excretes the infective pathogen back to the environment before being ingested by a new child host (route c). A fourth route of transmission is for pathogens that typically inhabit animals to be transferred to and colonize children via the environment (route d).

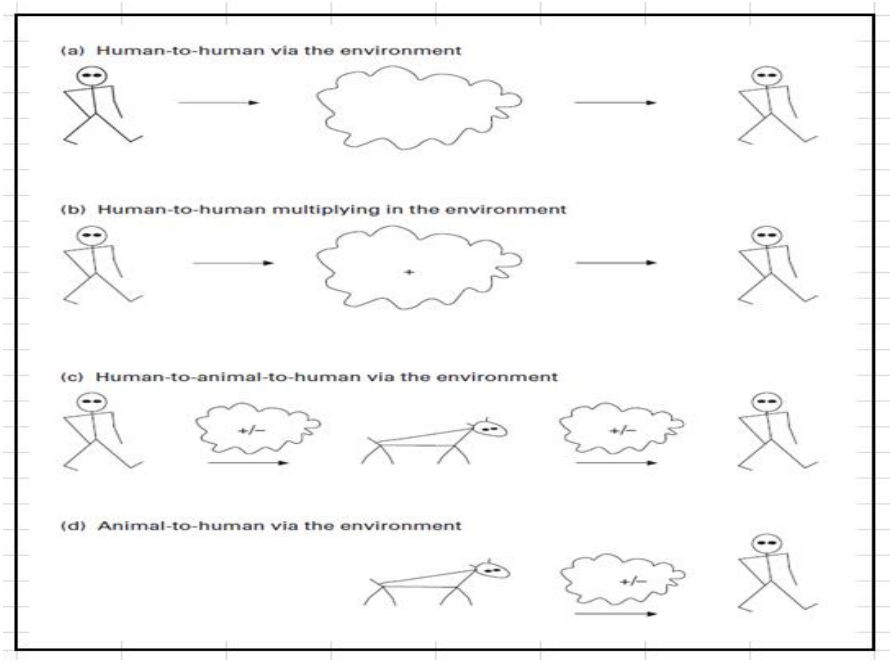

Figure 2.1: Schematic representation of transmission routes (Curtis, Cairncross and Yonli, 2000).

The above schematic representation is simple in presentation, yet each of the potential pathways sketched illustrates that the pathogen had to transverse and persist in the environment, implying that children's living and playing environments are potential secondary reservoirs for contracting diarrhoea.

Curtis, Cairncross and Yonli (2000: 24), Curtis and Cairncross (2003: 275) and WaterAid (2012: 15) further explained that exposure to excreta may result in bacterial pathogen transfer onto children's fingers and mouths and that the 'environment', the principal platform for childhood diarrhoea transmission is highly likely to include the child's household and immediate surroundings. Pathogens may also contaminate drinking water and food stored at ambient temperatures. The potential of carry-over of pathogens from faeces to food and the transfer of soil contaminated with faeces into households via flies and animals or humans, respectively, may become potential sources of diarrhoea, particularly where children eat and play.

The most frequent transmission pathway from faeces in the environment to a child is via the faecal-oral route. (WaterAid 2012). Figure 2.2 show that the key transmission pathways are through 'the five Fs', namely fingers, fluids, flies, fields/floors and food.

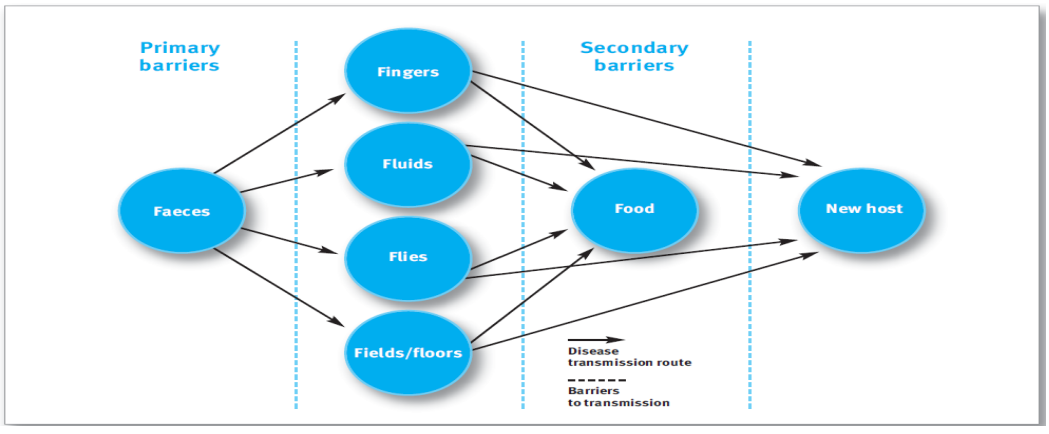

Figure 2.2: A visual representation of the transmission routes by which faecal material could be ingested, and ways to prevent this (WaterAid, 2012).

Children can therefore be exposed to these diarrhoeal or faecal pathogens, which may be subsequently ingested by all five routes as depicted in Figure 2.2. Waste-dump soil contaminated with excreta can also be carried and unknowingly deposited into homes by people and animals where children play, rest and sleep (WaterAid 2012: 15).

Majorin *et al*. (2014: 2) noted that children may be at a higher risk of diarrhoea caused by ambient enteric pathogens due to their length of time spent in faecally-polluted sites such as waste dumps and their natural tendency to place fingers and fomites into their mouths. Shivoga and Moturi (2008: 94) concluded that geophagia, the eating of soil, clay or earth was a major risk factor of diarrhoea ($P < 0.005$) among under-five children living in informal settlements in Kenya and overall the illness was positively correlated with human faeces (r=0.587) and animal faeces in yard areas (r=0.225). In addition, Xue *et al*. (2010: 536) performed a meta-analysis of children's object-to-mouth frequency patterns and concluded a higher frequency of both hand-to-mouth and object-to-mouth non-dietary ingestion exposure in the under-five age group. These collective findings are extremely relevant to this study because children under-five often played outdoors and are exposed to faecally-polluted waste dumps, thus making them highly vulnerable and sensitive to contracting acute diarrhoea by virtue of normal and frequent hand-to-mouth behavioural patterns.

Figure 2.2 shows that by implementing 'primary barriers' and 'secondary barriers' that prevent pathogens in faeces from entering the living, recreational, food preparation and eating environments, the risk of diarrhoea transmission among children could be prevented or significantly reduced. In addition to the living environments of children, feeding practices have also been implicated in childhood diarrhoea (Hung 2006: 17).

2.4.4 Breastfeeding and childhood diarrhoea

Horta *et al*. (2007: 123) explained that one of the most significant benefits of breastfeeding is the reduction in childhood mortality and morbidity from infectious diseases such as diarrhoea. This is evidenced in a study by Isaacs (2005: 1286) which explained that antimicrobial compounds in human milk attack pathogens at multiple points in their life cycles thereby inactivating pathogens such as DEC that are known etiological agents of childhood diarrhoea.

A cross sectional study undertaken in informal settlements of Bankura, West Bengal had shown that diarrhoea in children under-five was diagnosed in 20.33% and 31.57% of the exclusively breastfed and those breastfed for under 6 months, respectively. Overall bottle-fed children experienced 26.08% of diarrhoea compared to the incidence of 21.70% in breastfed children (Gupta *et al*. 2015: 27).

In 2011, the Minister of Health in South Africa released a media statement advising that government had adopted an exclusive breastfeeding strategy in view of the finding that only 8% of infants in the country were exclusively breastfed up to six months (Weideman 2013: 31).

2.4.5 Malnutrition and childhood diarrhoea

Rahman *et al.* (2014: 664) noted in their assessment of seven low and middle-income countries that among children aged 1-4 years, acute diarrhoea accounted for 31-69% of deaths and that more than 40% of these fatalities resulted amongst malnourished children. Nel (2010: 15) and Irena, Mwambazi and Mulenga (2011: 114) explained that diarrhoea and malnutrition has a bidirectional association, meaning that diarrhoea leads to malnutrition while malnutrition in turn, increases the severity of this illness. The two-way relationship between malnutrition and diarrhoea can therefore

have a detrimental effect among children who either contract acute diarrhoea or malnourished children that become infected with diarrhoeal pathogens. Therefore children living in informal settlements that are often plagued with extreme poverty, substandard living conditions and malnutrition (Unger 2013: 799) are highly susceptible to diarrhoea morbidity and mortality. Additionally, Pantenburg *et al*. (2014: 555) explained that the illness can be worsened when mothers and/or primary caretakers limit nutritional support during diarrhoeal episodes, thereby impacting on physical and mental childhood development.

2.4.6 Impact of diarrhoea on children

The impact of childhood diarrhoea has substantial long-term effects on nutritional status, growth patterns, level of fitness, cognition and school performance (Hung 2006: 19). Berkman *et al*. (2002: 569) and Schmidt (2014: 310) showed that stunting as a result of malnutrition and diarrhoea during infancy had adversely affected cognitive function in late childhood and that severe stunting in the child's second year equated to a 10-point reduction in intelligence quotient scores after adjustment for socio-economic, sanitation, schooling and other significant confounding variables. Therefore, it stands to reason that the consequential community burden of childhood diarrhoea translates into health, social and economic challenges, particularly among families living in impoverished regions.

2.4.7 Economic costs associated with childhood diarrhoea

Rheinigans *et al*. (2012a: 334) and Rheingans *et al*. (2012b: 325) explained that parents or caregivers are likely to incur reduced savings, diminished assets and increased debt which in turn places an escalated financial burden on the family particularly those living in poverty. Although the absolute value of household economic costs is relatively low for each childhood diarrhoeal

episode, the reality is that the high frequency of childhood diarrhoea in low-income regions translates into billions of dollars globally.

The costs associated with childhood diarrhoea impose huge financial and social burdens on the family unit where children are not only burdened with clinical illness but their parents or caregivers are also encumbered with economic hardship due to lost work days and medical expenditures (Pathela *et al*. 2006: 430). In order to avoid additional household economic difficulties, albeit on a micro-level, the study assessed mothers' and primary caregivers' KABP so that potential risks could be identified and necessary strategies be implemented, to prevent childhood diarrhoea within the study locations.

2.5 KNOWLEDGE, ATTITUDE, BEHAVIOUR AND PRACTICES (KABP) SURVEYS

KABP surveys are based on a theory that a parent's or caregiver's knowledge (facts) and their attitudes (positive and negative feelings and opinions) directly affect their family health status and outcomes (Katzenellenbogen, Joubert and Karim 1999: 169; eThekwini Municipality 2010: 15). Vandamme (2009: 01) and Shah *et al*. (2011: 66) explained that a KABP survey is utilized to investigate and establish what a specific population know (knowledge), how they feel (attitude) and what they do (practice) as a result of their educational status. Mengistie, Berhane and Worku (2013: 446) indicated that in addition to knowledge, attitudes and practices, the role of behavioural risk factors in the transmission or reduction of diarrhoea is vitally important, and has not been adequately understood at household and community level particularly in developing regions.

According to Ghasemi *et al*. (2013: 158), mothers more often than not, are the primary caregivers who manage and treat under-five children with diarrhoea in their households. Additionally, these caregivers are responsible for their nutrition and wellbeing, therefore their knowledge about childhood

illnesses such as diarrhoea is critically important. Jain, Oswal and Chitguppi (2014: 40) indicated that under-five children spend most of these years with mothers, during which early routines and habits are acquired. This includes learning healthy behaviour and practices which again highlights mothers' significant role in child health status including their suitability as respondents and participants in community-based studies involving under-five children.

Baseline information on demographics, socio-economic characteristics including age distribution, household occupancy, income status and mothers' educational levels in relation to their knowledge, attitude and practices towards waste management, transmission risks and management of diarrhoea were collected in KAPB studies amongst impoverished communities that assessed how these caregivers' personal variables, daily lifestyles and habits contributed towards their children contracting this illness (Oketcho *et al.* 2012: 83; Yilgwan and Okolo 2012: 221; Mengistie, Berhane and Worku 2013: 446; Choube *et al*. 2014: 285).

KABP studies have also been used to assess household waste management and its association with childhood diarrhoea. Yongsi *et al*. (2008: 162) found that exposure to unprotected household refuse accounted for approximately 87% of diarrhoeal cases in Yaounde, Cameroon. Rego *et al.* (2006: 722) investigated the relationship between diarrhoea and exposure to urban solid waste among pre-school children in Brazil and found the main factors associated with childhood diarrhoea prevalence included exposure to solid waste and wastewater in street, child age, hygiene and cleanliness near the house, number of occupants per household and drainage problems. Similarly, the data collected from the respondents in this study will provide a holistic assessment of community KABP which may be contributing to the risk(s) of children contracting diarrhoea from the settlements within which they reside and play.

According to Banjo, Adebambo and Dairo (2009: 62) and Aladesanni *et al*. (2014: 243) environmental education and awareness is a 'pre-condition for pro-environmental behaviour" which encompasses peoples' knowledge, attitudes, skills and behaviour to individually and collectively find solutions towards community environmental challenges including uncontrolled domestic waste dumping. These two studies have also identified women and scholars as key catalysts for recognizing and understanding the health effects associated with indiscriminate household waste practices and advocating for change to eliminate this neglected public health risk and community environmental challenge.

Data collected from the questionnaire administered to mothers of children under-five in this study also provided vital information regarding socio-economic characteristics, environmental hygiene and behavioural practices and how these factors contributed and/or exacerbated the incidence of childhood diarrhoea within the selected settlements. Pathela *et al*. (2006: 430) explained that understanding and evaluating risks of childhood diarrhoea required in depth knowledge of the complex interactions between biological, socio-economic, behavioural, and environmental factors over a period of time and within a given location.

Boadi and Kuitunen (2005: 32) and Sillah (2012: 41) investigated mothers' knowledge ($P = 0.0316$), attitude ($P = 0.0178$) and practices that contributed to childhood diarrhoea which showed that hygiene practices, clean water, adequate sanitation facilities including demographic and socio-economic characteristics and mothers' educational status ($P = 0.0465$) were identified as important risk factors for this illness.

2.5.1 Demographic, socio-economic factors and mothers' and/or primary caregivers' educational status

- **Age of Children**

A number of studies have shown that both the incidence and prevalence of diarrhoea was highest among children between 6 and 59 months of age (Okethcho *et al*. 2012: 82; Mengistie, Berhane and Worku 2013: 447; Mihrete, Alemie and Teferra 2014: 102). Okethcho *et al*. (2012: 83) explained that this trend likely resulted because of children's weak immune system and exposure to enteric pathogens whilst coming into contact with faeces when playing and crawling. Kyobutungi *et al.* (2008: 1) also found that the prevalence of diarrhoea is higher among younger children living in informal settlements and in particular, those under-five had more than four times the mortality burden than the rest of the population. This study also considered specifically the under-five age category as these children appear to be more vulnerable and predisposed to infectious diseases including diarrhoea.

- **Socio-economic factors**

Bozkurt, Ozgur and Ozcirpici (2003: 443) revealed that the annual mean incidence of diarrhoea was found to be 1.09 per child per year in a cohort study conducted in Turkey. The study also disclosed that the mean was higher in children resident in households with low socio-economic status compared with children living in households with higher income levels. Collinson, Tollman and Kahn (2007: 82) indicated that the concentration of poverty in informal settlements coupled with limited public resources also make children in sub-Saharan African countries particularly vulnerable to infectious diseases including diarrhoea.

- **Mothers education and literacy levels**

Yilgwan and Okolo (2012: 221) found that the association between maternal education and higher prevalence of childhood diarrhoea was statistically significant (odds ratio [OR] = 0.0769, 95% confidence interval [CI] = 0.01-1.47). Hussain and Smith (1999: 301) noted a strong association between mothers' educational status and the incidence of childhood diarrhoea amongst both rural and metropolitan areas in Bangladesh. The study showed that children of mothers with a high school level of education and above, were 60% less likely to have had diarrhoea than children of illiterate women. Hence the present study assessed similar relationships to understand potential contributory factors of childhood diarrhoea prevalent within the six study localities. In addition to demographics, household income and maternal educational status, a number of environmental risk factors have been reviewed to illustrate the contributory significance towards childhood diarrhoea.

2.5.2 Environmental risk factors associated with childhood diarrhoea

According to Sverdlik (2011: 126) a child's health status is directly affected by housing quality, living conditions and a multiple burden of environmental risks. In an informal settlement, the residents' health statuses are strongly influenced by:

- the siting and design of homes;
- the accessibility and safety of the water supply and sanitation; and
- the disposal of waste, including the control of pests.

According to Penrose *et al*. (2010: 1), Sverdlik (2011: 124), and Unger (2013: 801) "children are disproportionately affected by many environmental risks present within urban informal settlements due to their physiological vulnerability and urge to play even amid hazardous conditions". These risks included poverty, inadequate water supply, unsuitable sanitation, difficulty in

accessing health care, poor living conditions and inappropriately constructed housing which resulted in children having five times the risk of death from diarrhoea.

2.5.2.1 Quality of housing and living conditions

The associated risks of housing to health is varied, and is directly related to the availability, design, construction, internal environment and condition of the household and immediate surroundings, infrastructural services and the overall settlement design and density (Bailie and Wayte 2006: 178). Unger and Riley (2007: 1561) collated various data on informal settlements in South America, Asia and Africa and found that irrespective of where these settlements are located, its residents commonly live in squalid conditions. Szwarcwald, de Andrade and Bastos (2002: 2090); Sclar, Garau and Carolini (2005: 902) and Fotso (2006: 2) also showed that children's health outcomes due to their living conditions are significantly worse in informal settlements than in neighbouring urban areas or even rural areas. Sverdlik (2011: 123) found that children living in informal settlements are highly susceptible and suffered from disease, injury and premature death as a result of inherent environmental hazards including poor-quality housing.

Habib *et al.* (2009: 174) and Mutisya *et al*. (2010: 137) examined the association between housing quality and living conditions and found that the design and infrastructure of the household including sewage disposal (93%), electricity supply (31%), flooding due to heavy rainfall (13%), humidity (55%) and cracks in walls (40%) were associated with poor health among residents. Inadequate waste disposal systems in informal human settlements of the present study and rainfall created unsafe and unhealthy living environments and consequently as children played outdoors, they were directly exposed to contaminated waste and polluted flowing water, thereby increasing the chances of contracting bacterial infections such as childhood diarrhoea.

2.5.2.2 Waste management in informal settlements

Nweke and Sanders (2009: 867) noted that the collection of municipal solid waste in African countries is less than 20% which resulted in indiscriminate dumping. In South Africa municipal solid waste is typically collected and disposed of in landfill sites, however, as observed in the six informal settlements of the present study, the accumulation of waste in dumps was a common identified pattern.

The provision and management of waste removal services in informal settlements of the eThekwini Municipality is the responsibility of the Durban Solid Waste (DSW) Department. In an email communication on 03 September 2015, DSW area cleansing officer, N. Khuzwayo indicated that a system is in place for the collection of waste on a weekly basis from all informal settlements in the greater Durban area. The provision of a formalized waste removal service within the study areas seemingly cannot curb the sporadic occurrence and spread of waste dumps as a result of indiscriminate waste dumping and other anthropogenic activities.

A study by Kyobutungi *et al.* (2008: 5) revealed that unsatisfactory or inadequate household waste disposal and accumulation proliferated infectious disease agents, thereby making children living in informal localities more susceptible to health risks such as diarrhoea. The discarding of household solid waste into waste dumps and greywater disposal have been identified as significant sources of childhood diarrhoea and described below, namely:

- **Solid Waste**

Mohammed, Zungu and Hoque (2013: 106) explained that inadequate waste management, particularly in informal settlements posed a serious community health risk because the accumulation of solid waste is a source of

contaminants and disease agents. Therefore solid waste indiscriminately discarded and accumulated over a period of time may contribute to diarrhoea, vector-borne disease and the contamination of drinking and other water resources.

Domestic solid waste is usually referred to as municipal waste and is defined as “non-liquid material that no longer has any value to the person who is responsible for its generation”. “Garbage”, “waste”, “dirt”, “trash”, “refuse” and rubbish” or identified locally as “udoti” are terms often used as synonyms of solid waste in the EMA and is generated by domestic households, commercial and industrial activities (Zhu *et al*. 2008: 3).

In this study, solid waste within the six selected informal settlements included generation and disposal of household waste, human or animal excreta, seemingly due to a lack of adequate sanitation facilities and a large domestic and wild animal population that roamed amidst the vegetation and open waste dumps. Inadvertently, human activities within these informal human settlements created waste, and the way in which it is managed and subsequently disposed often posed significant risk to the environment and to the health of residents, particularly children.

According to Opisa *et al.* (2012: 2674) excessive environmental pollution and contamination caused by improper waste and excreta management are commonplace within peri-urban informal settlements located throughout the developing world. This phenomenon of indiscriminate dumping resulting in the formation of domestic open waste dumps within informal settlements is undoubtedly the existing status quo experienced within the EMA.

- **Domestic waste dumps**

The accumulation of solid wastes and domestic effluent (greywater) in informal settlements within the Durban area is an everyday reality and the culmination of these unpermitted and unmanaged open dump sites is cause for serious concern. There are a number of reasons for the increase in open waste dump sites within informal settlements.

A 2011 unpublished survey by the eThekwini Health Department of informal settlements in the greater Durban area concluded that common causes for indiscriminate dumping comprised as follows:

- Inconsistent formal collection of domestic refuse on a regular basis;
- Inadequate supply of refuse liner bags to informal settlement dwellers;
- General apathy and reluctance of residents to carry and store their domestic refuse at identified pick-up points;
- A lack of civic pride; and
- Ignorance, illiteracy and convenience among local informal communities.

The quantitative risk profiling of such dump sites has not been established to determine possible health impacts and risks to residents, particularly among children residing in these settlements. Young children living in these settlements are most vulnerable to potential health risks as they often play in and around these open waste dumps owing to a lack or non-existence of recreational facilities and open spaces as indicated in Plates 2.2 and 2.3.

Plate 2.2: Domestic waste dump (a mixture of waste, greywater and storm water runoff) found in the Puntans Hill Informal settlement (November 2013)

Plate 2.3: Children playing near a domestic waste dump (a mixture of waste, grey water and sewerage discharge) found in the Jadhu Place Hill informal settlement (September 2014)

In a study by Osunwoke and Kuforiji (2012: 59) that evaluated the health impacts of microorganisms, solid surface debris was removed from the point of collection from domestic waste dumps and the subsurface soil dug to a depth of about 15cm with a sterilized stainless steel teaspoon. Osunwoke and Kuforiji (2012: 60) subsequently concluded that bacterial microorganisms found in these waste-dump soils rapidly inhabited waste materials using its components as sources of nutrition for growth, survival and multiplication.

Therefore open waste dumps caused by indiscriminate dumping within the six study areas inevitably become ideal reservoirs of pathogenic bacterial agents that pose a realistic health hazard to the community. In view of the evident microbiological risks associated with waste-dump soil and accumulated waste, it becomes vitally critical to understand whether diarrhoeal-causing pathogens such as DEC may be contributing to the prevalence of childhood diarrhoea amongst children living in the chosen settlements. Additionally, greywater disposal within informal settlements in South Africa augments pathogenic bacterial growth as concluded by Carden *et al.* (2007: 433), thereby exacerbating the risks present within indiscriminate domestic waste dumps.

- **Greywater**

The apparent lack of suitable greywater drainage provision in most informal settlements across South Africa has resulted in largely polluted indoor, outdoor and recreational environments which contributed significantly to the burden of community disease including childhood diarrhoea (Armitage *et al.* 2009: 2341; Ashipala and Armitage 2011: 1781). Eriksson *et al*. (2002: 85) defined greywater as the “wastewater that is produced from household processes including cooking, washing dishes, laundry and bathing, without input from toilets”.

In South Africa, non-sewered informal localities are defined as “those areas without on-site waterborne sanitation” and also included “settlements with dysfunctional or inadequate sewerage systems, particularly communal toilet facilities” (Carden *et al.* 2007: 433). The six selected settlements contained communal toilet facilities which were often blocked, dysfunctional or in a state of disrepair. Due to non-sewerage of greywater in the chosen localities, residents often disposed greywater outdoors, directly onto ground surface or into domestic waste dumps near their dwellings (P.S. Dlamini - pers. comm. 14 April 2015). Evidently, greywater disposal via reticulated infrastructure and its treatment is generally not an option in most informal settlements and health risks including direct exposure to ‘greywater pathogens’ or ‘greywater contamination’ of drinking water (Carden *et al.* 2007: 436) at household level is an everyday reality.

2.5.2.3 Water-related factors

According to WHO (2011: 4) safe transportation, storage and consumption of water especially in informal settlements are important determinants in the incidence of childhood diarrhoea. However, Dasgupta (2008: 289) collected data from 300 households in three informal settlement locations in Delhi, India and found that households that adhered to safe storage practices of municipal drinking water did not translate into lower incidence rates of diarrhoea as compared to those residents that subscribed to relatively unsafe practices. Dasgupta (2008: 290) suggested that the explanation was due to external factors that were beyond the control of the individual, affected household.

Therefore, behavioural factors such as household water storage practices and indeed other risk factors discussed should not be analyzed in isolation as determinants of childhood diarrhoea. Although, this study aimed to prove the association between acute childhood diarrhoea and diarrhoeagenic *E.coli* present in contaminated soil, it should be noted that in reality, a number of

risk factors could contribute individually and holistically towards this highly prevalent community illness. The type of sanitation used by residents and children of the chosen informal settlements may also constitute an environmental risk of community acquired diarrhoea.

2.5.2.4 Sanitation factors

Barreto *et al*. (2007: 1622) investigated the epidemiological effect of a sanitation programme in which informal households were connected to a formal sewerage system in Salvador, Brazil. The intervention study found that prevalence of childhood diarrhoea decreased by 21% (95% CI 18 – 25%), that is from 9.2 days per child per year prior to the implemented sanitary intervention to 7.3 days per child per annum post-intervention in the under-three age group.

Checkley *et al*. (2004: 116) found that children with inadequate sanitation, water source and storage were 1.0 cm shorter in height with a 54% greater frequency of diarrhoea than children with better sanitation and water supply infrastructure and systems. The study also concluded that although improved water and sanitation infrastructure probably reduced exposure to faecal contamination, it however, did not have any effect on host response once the diarrhoea had occurred. Therefore, children exposed to faecal contamination in this study had a high probability of contracting diarrhoea.

In 2000, 13434 deaths resulted from unsafe and inadequate water, sanitation and hygiene which accounted for 2.6% of all deaths in South Africa. These mortality statistics included 9.3% of total deaths in children under-five (Lewin *et al.* 2007: 755). Thus household hygiene practices have also been implicated as a major risk factor of childhood diarrhoea.

2.5.2.5 Hygiene practices

In a study by Vinod *et al*. (2012: 445), the authors found that personal, unhygienic and domestic habits among informal slum dwellers in India predisposed both normal and malnourished children to illness with 49% in the under-five study group having experienced diarrhoea. Hassan *et al.* (2014: 1544) showed that 85% of children under-five also suffered with bacterial-related diarrhoea due to inadequate hygiene behavioural practices related to domestic animals frequenting internal eating rooms, poorly managed household waste, inadequate washing and bathing facilities and unsuitable water supply and storage.

George *et al*. (2014: 1193) found that a lack of caregiver personal and food hygiene-related knowledge accounted for 26% of the diarrhoea prevalence in the under-five age group. Godana and Mengistie (2013: 2326) identified the consumption of left-over food stored at room temperature as a significant predictor of acute childhood diarrhoea (P-value = 0.009) due to contamination with and the proliferation of diarrhoeal-causing bacteria.

Penrose *et al*. (2010:1) and Unger (2013: 801) noted that environmental risks within informal settlements have severe consequences for human health and particularly the transmission and spread of communicable diseases such as childhood diarrhoea. Therefore all potential environmental risks within communities must be identified, examined and evaluated holistically, in order to understand comprehensively, critical pathways leading to childhood diarrhoea.

As indicated in the preceding review, many studies have been conducted towards describing the epidemiology and risk factors of diarrhoea among children under-five. However, most studies (Lee and Puthucheary 2002: 26; Vargas *et al*. 2004: 537; Moyo *et al*. 2007: 92; Spano *et al*. 2008: 360; Sang,

Oundo and Schnabel 2012: 572; Sire *et al*. 2013: 139; Ifeanyi *et al*. 2015: 170) have focused on isolating bacterial pathogens from stool samples rather than identifying these pathogens from potential environmental or community reservoirs. This study however, specifically sought to isolate and identify one group of bacterial pathogens, namely DEC from contaminated soil in domestic waste dumps as etiological agents of childhood diarrhoea.

2.6 RELATIONSHIP BETWEEN DIARRHOEA AND BACTERIAL PATHOGENS

The second phase of the study investigated whether bacterial pathogens, specifically DEC are found in waste-dump soil located within informal settlements which are known etiological agents of childhood diarrhoea (Ramamurthy and Albert 2012: 44; Eseigbe *et al*. 2013: 452). Thus, the two-phased study approach provided a holistic assessment to determine whether a potential association between acute childhood diarrhoea and DEC present in waste dumps exist amongst the chosen settlements.

Amani, Mirhosseini and Fooladi (2015: 8) explained that bacterial pathogens such as DEC and their toxins induced diarrhoea and the number of cases has decreased to 1.6-2.1 million from approximately 4.6 million in the 1980s. However, Viswanathan, Hodges and Hecht (2009: 110) noted that whilst the global childhood mortality has in fact decreased since the eighties, the overall frequency of diarrhoea in children under-five had not changed significantly with an average of 3.2 episodes having being reported per child per annum.

Girbovan *et al.* (2012: 236) identified DEC as the most frequently isolated bacterial pathogen amongst children under-five with diarrhoea and indicated that the illness remains a huge challenge due to complexities associated with laboratory confirmation, diagnosis and treatment. Therefore, the second phase of study examined pathogenic *E.coli*, specifically DEC in waste dumps as potential reservoirs of childhood diarrhoea so that necessary interventions

and strategies could be implemented to reduce childhood diarrhoea amongst the study populations.

In an effort to understand and correlate potential associations between environmental risks, DEC and acute diarrhoea, it was logical to obtain a fundamental understanding of *E.coli* as both a commensal and pathogenic bacterial agent.

2.7 *Escherichia coli*

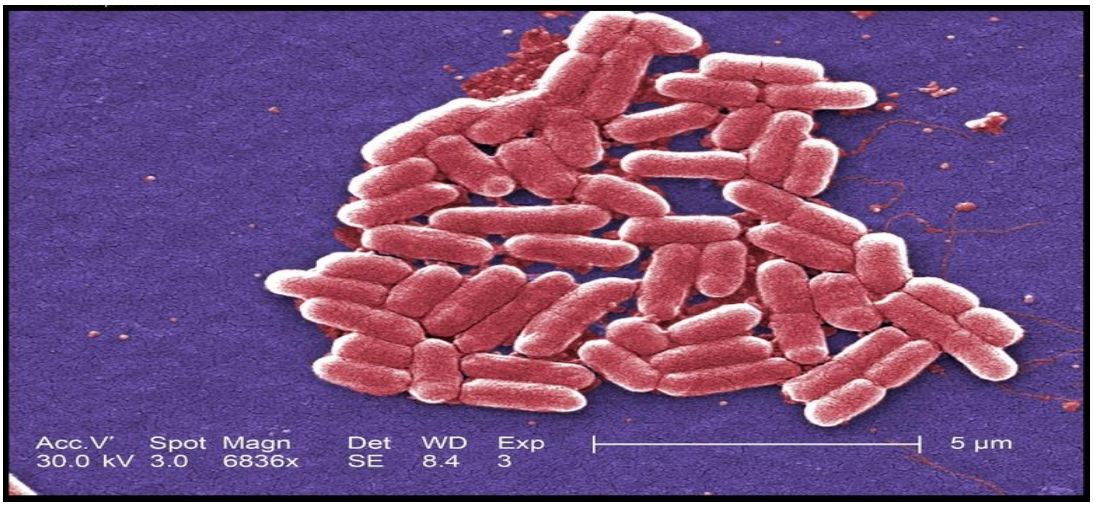

Figure 2.3: A typical scanning electron micrograph of *Escherichia coli* (strain O157:H7) (CDC 2006: 3).

Jeffery and van der Putten (2011: 17), Ramamurthy and Albert (2012: 44) and Yunlin *et al*. (2014: 1) explained that *E.coli* is an ever-present constituent bacterium of all human beings and is prevalent within the human gut, its primary reservoir, which may not necessarily cause disease. However, certain *E.coli* strains as depicted in Figure 2.3, known as pathogenic *E.coli* or DEC produced toxins which caused disease including diarrhoea in children. The severity of diarrhoea is dependent on the child's health before contracting the illness including the DEC strain and its associated toxin (Jeffery and van der Putten 2011: 17).

In the early 20th century, the first disease-causing or 'pathotype' of *E.coli* known as enteropathogenic *E.coli* (EPEC) was isolated as an etiological agent of childhood diarrhoea and more recently with the advent of techniques in virulence and pathogenesis, other categories of DEC were discovered. Each pathotype of *E.coli* had evolved by acquiring specific sets of virulence genes through mobile genetic elements-plasmids, transposons and bacteriophages. The factors encoded by these virulence genes affect a variety of cellular processes including protein synthesis, cell division, cytoskeletal function, apoptosis and water and electrolyte transport. In addition, because of the genome plasticity of *E.coli,* new pathogens will continue to evolve (Nataro and Kaper 1998: 147; Kaper, Nataro and Mobley 2004: 123; Ramamurthy and Albert 2012: 11).

Faruque (2012: 04) explained that DEC pathotypes possess specific fimbrial antigens that allow these pathogens to rapidly and abundantly cause infection by colonizing and adhering to a suitable mucosal site, evading the host's defenses, multiplying and then ultimately inducing diarrhoea in children. Grabow *et al.* (2003: 2) explained that genetic elements, which carry one or more genes responsible for the production of virulence genes are carried by specific phages which transfer these elements from one *E.coli* bacterium to another. Infection of a bacterium by one of these phages will convert the bacterium into a pathogen. These phages are known to occur in the environment and they act as a reservoir for the genetic elements which code for the production of the virulence factors. Hence virulence factors enable bacteria such as DEC to survive in hostile environments including open waste dumps (van Eslas *et al*. 2011: 176; Dalebroux *et al*. 2010: 171).

Figure 2.4 provides a schematic representation of the various reservoirs and transmission pathways that could lead to infection amongst children.

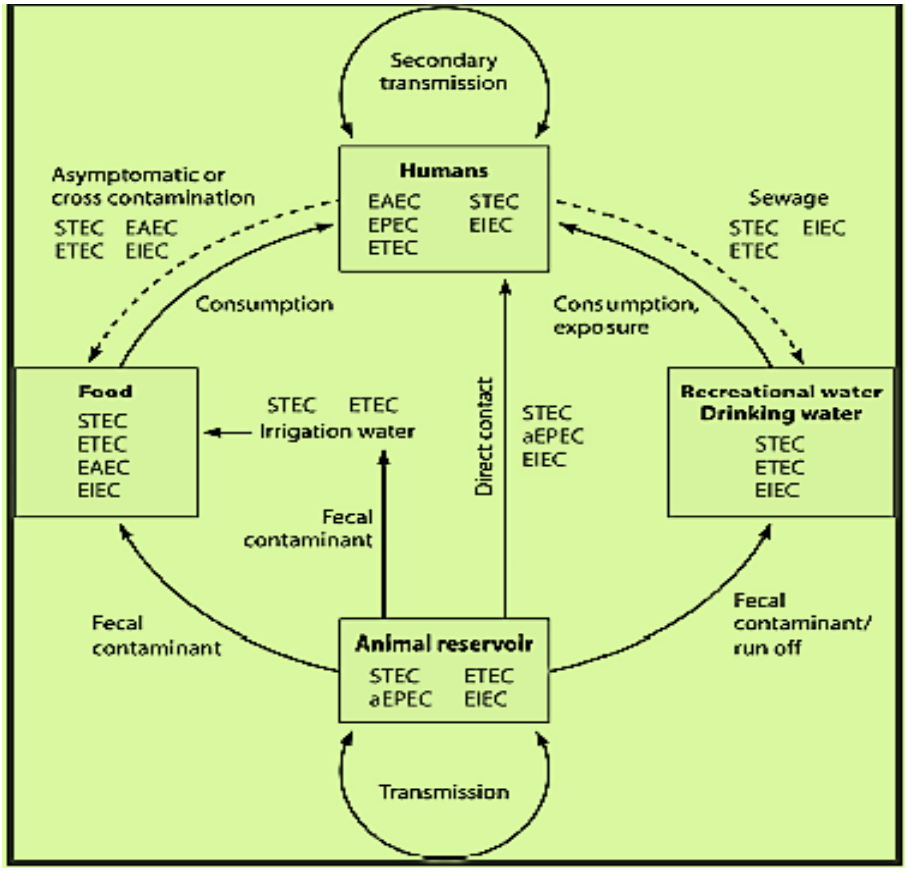

Figure 2.4: Overview of DEC reservoirs and transmission routes in the environment (Croxen *et al*., 2013).

Figure 2.4 shows that DEC pathogens can be transmitted from animal reservoirs via faeces which can subsequently infiltrate and contaminate food, water used to irrigate crops, potable and recreational water. Human hosts and particularly children can become exposed to these faecally-polluted media and contract DEC infection. Secondary transmission includes child-to-child contact which is common in creches, cross-contamination between raw and cooked foods, asymptomatic food handlers contaminating foodstuffs or from contact with recreational water bodies (Croxen *et al*. 2013: 830).

This study, however, specifically examined whether DEC pathotypes which are able to survive in waste dumps are potential sources of diarrhoea among children under-five that reside within the selected study areas.

2.8 DIARRHOEA AND DIARRHOEAGENIC *E .coli*

Studies (Black *et al*. 2010: 1969; O'Ryan *et al*. 2010: 671) have reported DEC as the most frequent bacterial etiological agents associated with acute childhood diarrhoea, however these frequencies varied with geographic region and depended largely on community socio-economic and sanitary conditions achieved. Faruque (2012: 1) indicated that it therefore becomes critical to understand the molecular basis of pathogenesis of DEC and its evolution and spread in the environment in an effort to develop and implement new prevention strategies for childhood diarrhoea.

Depending on its numerous and specific virulence factors, including adhesins, invasins, toxins and secretion, DEC pathotypes then invade human and animal hosts and cause diarrhoea (Willey, Sherwood and Woolverton 2008: 986). Six well-characterized subgroups or pathotypes, namely enterotoxigenic *E.coli* (ETEC), enteropathogenic *E.coli* (EPEC), enterohaemorrhagic *E.coli* (EHEC), enteroaggregative *E.coli* (EAEC), enteroinvasive *E.coli* (EIEC) and diffusely adherent *E.coli* (DAEC) may cause diarrhoea in children based on clinical, pathological and epidemiological characteristics of each pathotype (Willey, Sherwood and Woolverton 2008: 986). In addition to the six pathotypes, Croxen and Finlay (2010: 26) noted two other extra-intestinal pathotypes (ExPEC) which are known as uropathogenic *E.coli* (UPEC) and neonatal meningitis *E.coli* (NMEC). The six diarrhoeagenic and two extra-intestinal pathotypes are able to colonize various sites in children as depicted in Figure 2.5.

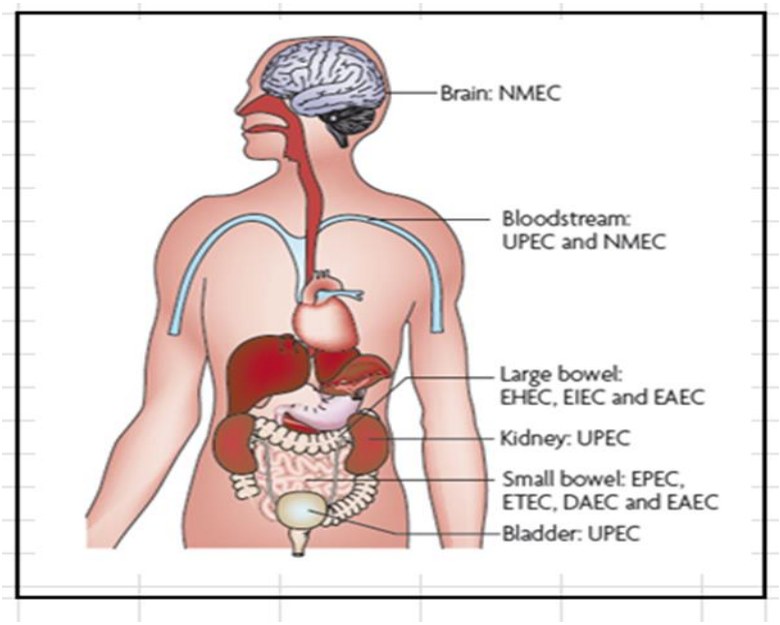

Figure 2.5: Sites of *E.coli* colonization in the human body (Croxen and Finlay, 2010).

DEC pathotypes, namely EPEC, ETEC, DAEC and EHEC and EIEC colonize the small and large bowels respectively, whilst EAEC are able to invade both areas of the intestinal tract. UPEC uses a different mechanism for host infection by first entering the urinary tract and later progressing into the bladder to cause cystitis and if this condition is untreated, the pathogen may then infiltrate the kidneys to cause pyelonephritis. Septicaemia can develop with both UPEC and NMEC infection and the latter is also a frequent causative agent of infant meningitis. The present study included the examination and analysis of soil samples for all eight DEC pathotypes as depicted in Figure 2.5, however, only the six DEC pathotypes will be considered as possible etiological agents of childhood diarrhoea. Table 2.2 provides a summary of clinical, pathological and epidemiological characteristics associated with the principal pathotypes of DEC.

Table 2.2: Summary of clinical, pathological and epidemiological characteristics of disease caused by DEC (Baqui *et al*., 1992; Nataro and Kaper, 1998; Kaper, Nataro and Mobley, 2004; Bonacorsi and Bingen, 2005; Pavankumar and Sankaran, 2008; Ramamurty and Albert, 2012 and Mittal, Sharma and Chaudary, 2014)

***E.coli* pathotype**	**Clinical Syndrome**	**Intestinal pathology**	**Population at Risk**
ETEC (enterotoxigenic *E.coli*)	Watery diarrhoea	Attaches to small intestine mucosa through colonization factor antigens	Children in developing countries and travellers to these countries.
EPEC (enteropathogenic *E.coli*)	Non-specific diarrhoea	Attaching and effacing lesion in the small intestine	Children under 2 years of age in developing countries.
EIEC (enteroinvasive *E.coli*)	Dysentery	Inflammation of the large intestinal mucosa.	Affect all age groups worldwide, but more common in developing countries.
EHEC (enterohaemorrhagic *E.coli*)	Bloody diarrhoea and haemolytic uraemic syndrome	Haemorrhagic colitis and attaching and effacing lesions in the large intestinal mucosa.	Children and the elderly in developed countries.
EAEC (enteroaggregative *E.coli*)	Persistent diarrhoea	Thick mucus-containing biofilm encrusted with bacteria; cytotoxic change in enterocytes.	Children in developing countries and travellers to these countries. Cause of AIDS-associated diarrhoea.
DAEC (Diffusely adherent *E.coli)*	Watery diarrhoea	Attaches to small intestine mucosa inducing inflammatory bowel diseases	Children >12 months in both the developing and developed world
UPEC (Uropathogenic *E.coli*)	Cystitis and pyelonephritis	Colonizes periurethral area, ascends the urethra to urine bladder, attaches and invades epithelial cell	Cystitis and pyelonephritis (urinary tract infections more common in females)
NMEC (Neonatal meningitis *E.coli*)	Neonatal meningitis / septicaemia	After acquisition from the mother's flora or from environment, *E. coli* colonizes the infant - into bloodstream/brain	Neonatal meningitis / septicaemia < 28 days, or in <3 months in 10% of cases

It is evident that DEC pathotypes as presented in Table 2.2 are the responsible etiological agents of childhood disease, particularly diarrhoea. Therefore understanding the acquisition of these pathogenic strains from the environment including soil, water and greywater as potential reservoirs becomes critical in mitigation of transmission risks of childhood diarrhoea.

2.9 *E.coli* IN SOIL, WATER AND GREYWATER

2.9.1 *E.coli* in soil

Soil from the natural landscape is a constituent of waste dumps. Awisan *et al*. (2011: 34) and Baumgardner (2012: 735) found that pathogenic *E.coli* may enter this media after contamination by sewage, human or animal waste and through untreated domestic wastewater disposal. Therefore DEC as soil transmitted pathogens may play an important role in the emergence of community-acquired infections such as childhood diarrhoea.

Brennan *et al*. (2010: 2175) noted that both its metabolic versatility and simple nutritional requirements allow and promote *E.coli* survival and multiplication in nutrient-rich soils of tropical and subtropical regions. Chandler and Craven (1980: 553) explained that the survival of *E.coil* in soil for extended periods enables this pathogen to infect the host post-exposure. The length of time of *E.coli* in this media is largely dependent on moisture content, with some strains able to survive for 14 days in dry soils and a further duration in wet soils. Jeffery and van der Putten (2011: 17) found that the survival of *E.coli* in compost heaps was also affected by moisture content but in contrast, these species were capable of surviving higher temperatures, 54-67°C and at lower moisture content, although survival of this pathogen was recorded in minutes as opposed to days.

In another study, Avery *et al*. (2004: 2102) demonstrated that pathogenic *E.coli* strains survived on surface vegetation and flora for up to 6 weeks and in its underlying soil for 8 weeks. Therefore the survival and growth of *E.coli* within soils particularly in waste dumps can act as a potential secondary reservoir of childhood diarrhoea and understanding the ecological characteristics of this pathogen in the environment becomes essential for assessing the risk to children from activities such as indiscriminate dumping and accumulation of refuse within informal settlements. Brennan *et al*. (2010: 2175) indicated that *E.coli* in soil may further contaminate water bodies which are commonly associated with microbiological or faecal pollution.

2.9.2 *E.coli* in water

Evidently, there is a lack of meaningful information on the ability of *E.coli* to proliferate and survive within drinking water systems, however Obi *et al*. (2007: 539) investigated the presence of bacterial pathogens from HIV/AIDS patients with and without diarrhoea including their daily household drinking water supply in Limpopo Province. The study identified *E.coli* as the most frequent enteric-pathogen isolated from both the potable water of these subjects and their stool samples. Obi *et al*. (2007: 540) concluded that a lack of proper water storage containers, containers left uncovered and poorly washed and disinfected containers contributed to the contamination of pathogenic *E.coli* in the drinking water. Informal settlement dwellers may therefore, be exposed to bacterial infection by ingesting contaminated drinking water.

In addition, surface and subsurface water may also be potential sources of *E.coli* contamination. Govender, Barnes and Pieper (2011: 7) assessed the contribution of faecal pollution as a result of inadequate environmental sanitation and housing quality towards community diarrhoea incidence in low-cost housing settlements of Cape Town. The authors noted that a lack of wastewater disposal facilities resulted in *E.coli* contamination and the

consequent surface runoff water was found to infiltrate storm water channels, thereby polluting rivers which become further sources of infection. The study also revealed that a total of 153 participants, particularly children under-ten living in informal dwellings situated in the backyards of low-cost housing units had experienced diarrhoea two weeks prior to the survey (Govender, Barnes and Pieper 2011: 9).

Although all six study areas have access to reticulated water via stand pipes and do not depend on catchments such as rivers, wells, springs or boreholes, the drinking water used for domestic purposes may still be at risk of *E.coli* contamination particularly during collection, storage and handling at household level. In South Africa, the Department of Water Affairs and Forestry's White Paper of 1994 defined basic water provision as access to potable water from a communal tap or stand pipe which is within 200 metres of the dwelling (Department of Housing 2000: 16).

However, due to rapid urbanization and population growth, particularly among informal settlements, the access of water from these stand pipes may become strained as more families may be accessing water from a single tap and the distance of accessing a stand pipe may be even greater than 200 m. Consequently, greater volumes of wastewater are generated and the risk of contact with contaminated water may be significant among settlement dwellers due to the absence or lack of adequate greywater disposal facilities.

2.9.3 *E.coli* in greywater

Eriksson *et al*. (2002: 89) explained that "infectious pathogens may be introduced into greywater by handwashing after toilet use, washing of babies, diaper changing and washing, including washing of uncooked vegetables and raw meat". O'Toole *et al*. (2012: 4301) assessed the microbial quality of greywater from 93 households in Australia and 185 samples were analyzed for *E.coli.* A total of 23 (21%) greywater samples tested positive including a

3% detection of pathogenic *E.coli* strains. The results of this study confirmed and revealed that greywater is a potential transmission pathway of DEC pathogens. Therefore the disposal of greywater into common waste disposal sites within the study areas may become potential sources or reservoirs of community acquired illness such as childhood diarrhoea.

The present study examined waste-dump soil which was contaminated with solid waste residues and greywater to investigate whether DEC are potential etiological agents that contributed to the incidence and prevalence of childhood diarrhoea within the six selected informal settlements. The implications of poor greywater disposal are therefore likely to impact residents in the selected settlements as there was no infrastructure for the discarding of this liquid waste. The presence of vectors such as flies, rats, cockroaches and domestic animals which are known to transmit pathogens were also observed within waste dumps in this study.

2.10 MECHANICAL VECTORS OF *E.coli* TRANSMISSION

Although the present study did not specifically examine vectors or domestic animals for the presence of DEC, a number of studies (Tachbele *et al.* 2006: 39; Gortazar *et al*. 2014: 01) revealed that DEC may be transmitted from vermin and animals to humans and exposure to these zoonotic pathogens is dependent on interactions between infected animal reservoirs and/or vector hosts or their environment. Therefore it is likely that vectors such as rodents, flies, cockroaches and domestic pets and wild animals which are known to invade or encroach informal settlements (Moiloa 2007: 73) may transmit DEC pathogens to households that could potentially lead to childhood diarrhoea via the ingestion of contaminated food or drinking water or from fingers of children.

2.11 RELATIONSHIP BETWEEN *E.coli* and WASTE

The accumulation of wastes and its consequent decomposition results in the proliferation of a variety of pathogens including DEC. Therefore the potential risks from residual composite soil in indiscriminate waste dumps found in and around shack dwellings and common sites in informal settlements remain highly significant. Achudume and Olawale (2007: 154) noted that walkways, play areas, entryway soil and child's hands are alternative ways in which children contracted infectious pathogens including DEC depending on their active participation and the time spent in or near waste dumps or common sites that contain waste residues.

Avery, Killham and Jones (2005: 821) assessed the persistence of DEC, specifically O157:H7 serotype, and the potential risks associated with organic wastes spread to land. The study found that the long-term storage of organic wastes led to a gradual decline in *E.coli* O157:H7 cells but did not completely eliminate these pathogens. They concluded that waste components accumulated on ground surface will exacerbate the environmental spread of DEC. The objective of sampling and analyzing soil containing a mixture of waste residues and greywater from dump sites in the present study was critical in assessing whether DEC were potential etiological agents of community acquired childhood diarrhoea.

The preceding extensive literature review has included a number of pertinent subsections that may contribute individually and holistically to the incidence and prevalence of childhood diarrhoea within informal settlements in Durban. Chapter 3 details the two-phased methodology that was undertaken in order investigate the association between acute childhood diarrhoea and DEC present in contaminated soil in informal settlements in Durban.

CHAPTER 3

METHODOLOGY

3.1 OVERVIEW

This study constituted a quantitative cross-sectional design. The methodology for each objective will be presented independently and in a sequential manner below.

OBJECTIVE 1:

Using a validated questionnaire, the first phase of the study collected information, regarding KABP of mothers and/or primary caregivers related to domestic waste management and community risk factors that may contribute to the observed incidence of childhood diarrhoea.

Questionnaire administration was concluded over four weeks in December 2014. The Statistical Package for Social Sciences (SPSS) Version 23.0 was used for data entry and analysis. Data was presented as simple frequencies and percentages and descriptive statistics in the form of tables and charts were used to describe demographic and socio-economic characteristics, mothers' education, knowledge, attitudes, practices and behaviour in relation to waste management including risks and management of childhood diarrhoea. Inferential statistics was performed using the Fisher's Exact test, Chi Square test and correlations related to respondent educational status and household practices and behaviour were determined.

OBJECTIVE 2:

The second phase of the study included the sampling and analysis of contaminated soil from waste dumps to determine whether DEC are highly probable etiological agents of childhood diarrhoea. Through a series of standard microbiological techniques, including isolation of presumptive *E.coli*, presumptive *E.coli* identification and molecular confirmation of *E.coli*, the positively identified environmental *E.coli* isolates were then subjected to a monoplex and/or multiplex Polymerase Chain Reaction (PCR) in order to determine the virulence gene signatures for the proper classification of these isolates into the different pathotypes.

Statistical analyses of phase 2 included descriptive analysis which was followed by bivariate analysis using the Pearson's chi squared test.

OBJECTIVE 3:

Based on the *E.coli* pathotypes found in objective 2 above, a further literature review was performed to show similar associations between DEC strains identified as causative agents of childhood diarrhoea as shown in documented epidemiological studies worldwide.

The statistical analyses for the second phase of study were performed using SPSS 23.0. All data were analyzed using descriptive statistical analysis (95% confidence limit). Means (± standard deviation) were calculated for presumptive *E.coli* counts and DEC pathotypes identified in waste dumps across all six settlements. The Pearson's product-moment correlation coefficient matrix was calculated to determine the relationship between identified DEC pathotypes and potential risk of exposure from children playing in polluted sites in their settlements.

3.2 METHODS FOR KABP STUDY (PHASE 1)

3.2.1 STUDY DESIGN

A KABP questionnaire was administered to mothers or primary caregivers of children <5years old within the six selected informal settlements.

3.2.2 STUDY POPULATION

The study population consisted of mothers and/or primary caregivers of children in the <5 years age category from six peri-urban squatter settlements located in the greater Durban area namely, Jadhu Place, Puntans Hill, Lacey Road, Burnwood, Foreman Road and Kennedy Road informal settlements. Table 3.1 below provides a summary of the study areas with the corresponding number of the estimated individual shack dwelling units and the actual count of households that were comprised of children less than 5 years of age as profiled by a research team in January 2014.

Table 3.1: Summary of study population, sample size and proportional breakdown of respondents to be interviewed

Informal Settlements	Estimated No. of Shacks	Households with children (< 5 years of age)	Required sample Size: (Proportional representation of households with children 0 – 4 years of age (n = 360)
Puntans Hill	415	182	22
Jadhu Place	1200	425	52
Kennedy Road	2147	941	115
Foreman Road	1550	800	98
Lacey Road	202	200	24
Burnwood	538	400	49
	6052	2948	**n = 360**

The total number of households that consisted of this age group was n = 2 948. Protocol dictated that in order to conduct research within informal settlements located in eThekwini Municipality, a submission of notification and summary of information to the eThekwini Municipality Health Unit (Annexure A) and the local ward councillor (Annexure B) was necessary.

3.2.3 SAMPLE SIZE AND SELECTION

Five community health workers (CHWs) employed within the six selected informal settlements were tasked with visiting each household to assess the total number of households that comprised of children between 0 - 4 years of age.

Raosoft Sample Size calculator was used to determine the sample size using the following parameters: a margin of error of 5%, confidence interval of 95%, the population of households having children 0 - 4 years of age within each settlement (Table 3.1) and an expected response rate of 50%. As suggested in Table 3.1, a total sample size of n = 360 households was required. Table 3.1 also provides a summary of the calculated proportional breakdown of the minimum sample size or number of respondents that had to be interviewed within each study subgroup. The sample size comprised of biological mothers (n = 329), biological fathers (n = 30) and a grandmother.

3.2.3.1 Inclusion Criteria

All households that had one or more children <5 years old having experienced a bout or episode of diarrhoea one month prior to date of interview were eligible for the study. In cases where the biological mother of the child was deceased, temporarily living apart from child or was unavailable due to employment demands or other commitments, the primary caregiver / guardian of the child was then recruited as a potential respondent. All respondents and children were permanent residents of their respective

communities. In pre-selected households, if a mother and child that met the inclusion criteria above could not be found, then adjacent households were visited until a suitable interviewee consented to participate in the study.

3.2.3.2 Exclusion Criteria

Children <5 years old with known medical conditions, including those who were diagnosed with intestinal diseases, irritable bowel syndrome, food intolerance and individuals who experienced adverse medication reactions were excluded from the study.

3.2.4 COLLECTION OF DATA

3.2.4.1 Study Instrument: Questionnaire

The questionnaire included various questions relating to demographics, socio-economic status and domestic water, sanitation and solid waste practices common in slum type settings. These were adapted with permission from a study by the Makerere University, Uganda (Annexure C: Letter from the Makerere University granting permission to cite, modify and use various documents). Additionally, a literature review of similar KABP studies was conducted to identify investigative questions to specifically assess the risks and prevalence of childhood diarrhoea. In total, the questionnaire consisted of 113 items, with a level of measurement at a nominal or an ordinal level.

All questionnaires were available in English and isiZulu (Annexure D). The English version was translated into isiZulu and back-translated to ensure that both versions were truly equivalent and valid for understanding, language and content. In addition, the accuracy and meaning of the translated version was checked by pre-testing the translated tool amongst the five CHWs for comprehension and where necessary, recommended amendments were implemented so that the questions were easy to understand and answer. The

questionnaire contained open and close-ended questions including five-point Likert scale questions ranging from “strongly agree” to “strongly disagree’ to assess respondent knowledge, attitudes, behaviour and practices related to social and environmental determinants of childhood diarrhoea.

3.2.4.2 Pilot study

To test for content, design, readability, validity and reliability, the questionnaire was piloted in the Cato Crest informal settlement situated south west of the Durban central business district. The suitability of this settlement was based on its similar demographic and socio-economic profile in relation to the chosen study areas. A total of n = 5 households were visited between 17th and 18th November 2014 and mothers of children <5 five years of age were interviewed.

Two minor changes relating to the inclusion criteria and an insertion that allowed respondents to choose multiple options for a particular question respectively, were effected in the data tool. The pilot study also revealed that whilst the questionnaire comprised closed and open-ended questions, the overall questionnaire was clear and structured to avoid ambiguous answers. The average time spent during each face-to-face interview in the pilot study was longer than initially anticipated which consequently required fieldworkers advising the n = 360 eligible respondents of approximate duration before they proceeded with interview.

3.2.4.3 Recruiting and training of interviewers

During the planning and proposal stage, five CHWs operational within the selected settlements agreed in principle to participate in the study. However, due to the high number of respondents required to be interviewed and the lengthier time necessary to complete the interview session, two additional

CHWs were recruited to assist with the administration of the questionnaire within the Kennedy and Foreman Road localities.

The seven CHWs were individually trained and guided to administer and conduct interviews with eligible respondents on 28th November 2014 (Annexure E). The training session also included simulated interviews in which the CHW was able to demonstrate their understanding and proficiency of all questions in both languages. An agreement between the researcher and the CHWs were signed prior to commencement of fieldwork (Annexure F).

3.2.4.4 Administration of questionnaire

The questionnaire was administered to mothers and/or primary caregivers of children <5 years of age during December 2014. Face-to-face interviews were conducted among households that met the inclusion criteria. Two days prior to commencement of questionnaire administration, the prescribed number of printed copies and stationery were delivered to each of the fieldworkers including a brief refresher session to remind them of basic and minimum procedures that had to be consistently followed before, during and after interview sessions for the duration of the KABP community study.

Following due consideration of stipulated selection criteria, a subject or letter of information sheet (Annexure G) was handed to each respondent and subsequent written informed consent (Annexure H) was sought and granted from mothers and/or primary caregivers who agreed to participate. It was also noted that all respondents completed the questionnaire sessions with the knowledge and reassurance of being able to withdraw from study at any time.

Respondents were interviewed according to their availability and convenience which included weekends and evenings. Questionnaires and corresponding informed consent letters were collected and collated for each study area to ensure that relevant returns were received in good order, misplaced documents retrieved and data checked to identify omissions and errors. Collected data sets were then stored in labelled boxes in a locked premises until suitable data quality assurance and management systems were established.

3.2.5 DATA MANAGEMENT

The raw data i.e. information from the 360 questionnaires of the KABP study and data pertaining to the positive *E.coli* strains including differentiation of *E.coli* pathotypes was coded and captured in Excel 2014. It was then imported into SPSS version 23.0 where all the necessary codes and data measures were finalised. Missing data due to non-responses by respondents was treated as system missing data. The various statistical procedures were run using the Analyse function in SPSS. Results from the Output SPSS file were exported to Excel to enable the generation of tables and graphs.

3.2.6 DATA ANALYSIS STRATEGY

A search of the literature has revealed that community KABP towards DWM and social and environmental determinants influencing childhood diarrhoea incidence and prevalence is usually and most commonly guided by mothers' and/or primary caregivers' knowledge, assessment, interpretation and perception of these risk factors (Boadi and Kuitunen 2005: 2; Banjo, Adebambo and Dairo 2009: 64; Usfar *et al*. 2010: 34; Sillah 2012: 9).

In addition several other epidemiological studies have shown that mothers and/or primary caregivers' educational status in relation to their KABP in recognizing causes, definitions, symptoms, environmental risks, prevention

and management of childhood diarrhoea in both rural and urban locations are of paramount importance in assessing community, household and social risk factors towards this illness (Ansari *et al*. 2009: 235; Haroun *et al*. 2010: 141; Ansari *et al*. 2012: 218; Sillah, Ho and Chao 2013: 1368; Oloruntoba, Folarin and Ayede 2014: 1001). The chi-square test was used to assess associations between mothers' educational status in relation to their KABP to understand overall community perceptions and beliefs that may contribute towards domestic waste practices and childhood diarrhoea.

A $P < 0.05$ was considered statistically significant and where appropriate, 95% confidence intervals were also calculated. Data pertaining to demographics, socio-economic status, water usage, sanitation, and knowledge, attitudes, behaviour and practices pertaining to domestic waste management and childhood diarrhoea was captured using Microsoft Excel 2014 and then imported into SPSS version 23.0 allowing for simple descriptive statistics to be generated.

Descriptive statistics was used to present percentage representations of data collected from completed questionnaires. Descriptive statistics included the use of frequency tables, various types of charts, primarily pie and bar and cross-tabulations. Numerical measures of descriptions included the mean, median and standard deviation.

Factor analysis was used to determine the underlying themes in the questionnaire and to identify variables or factors from the KABP that will attempt to explain the pattern of correlation between the risks of contracting childhood diarrhoea from potential exposure to waste dumps and other risk factors inherent within the settlements. Prior to the execution of the factor analysis method using Varimax rotation, conditions requiring that the Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test were also tested. Reliability statistics were used to determine the consistency of scoring

for the ordinal statements in the various sections using Cronbach's Alpha. The acceptable minimum level of Cronbach's Alpha is 0.70.

3.2.7 ETHICAL ISSUES

Fieldwork for questionnaire administration commenced upon receipt of ethical clearance from the Durban University of Technology, Institutional Research Ethics Committee (Ethics Clearence reference number: IREC 078/14). To ensure integrity and confidentiality of respective subject data, all collected paper versions will be maintained under locked storage and subsequently destroyed after the stipulated post examination time period.

The 360 respondents that participated were interviewed at their convenience and on a completely voluntary basis. Selected respondents were handed letters of information (Annexure G) that explained the purpose and intent of study and upon willingness to participate, first signed and returned written consent documentation (Annexure H) to fieldworkers. In addition, the questionnaire, subject information and consent letters had also been translated into isiZulu for easier understanding and interpretation with the assistance of trained bilingual interviewers.

3.3 METHODS FOR SOIL SAMPLING OF WASTE DUMPS (PHASE 2)

3.3.1 STUDY DESIGN

Phase 2 constituted an experimental study that comprised of waste dump soil collection and transportation to University of KwaZulu-Natal (UKZN) Microbiology Laboratory on 9 February 2015, for examination and analysis of DEC as etiological agents of childhood diarrhoea.

3.3.2 DESCRIPTION OF CONTAMINATED SOIL STUDY SITES

In this study, six open domestic waste dumps sites within the selected informal settlements (as described previously) were chosen for investigation. The chosen indiscriminate open waste sites constituted a mixture of soil, solid waste components, natural biota including leaves, plants, twigs, grass and weeds. These were further characterized by both direct environmental pollution activities including open human, domestic and/or wild animal defecation, discarding of household waste, disposal of greywater and indirect activities such as stormwater runoff and wastewater seepage due to damaged and defective community ablution facilities. The proximity of the dump sites in relation to the location of individual shack dwellings, ranged from a few to approximately 100 m.

The waste dumps located within the six study areas varied in the following ways:

- The nature, constituents, composition, quantity, volume, proportions, extent and depth.
- Its existence was dependent on weather and seasonal changes, burning of waste heaps, community clean-up campaigns and clearing and removal of waste dumps by engaged waste removal contractors.
- The number of waste dumps present during the study period fluctuated with a minimum of four sites identified in each of the six locations.
- The siting of these dumps also varied according to the topography, terrain and natural vegetation and open spaces found within the respective communities.

3.3.3 SAMPLE SIZE

A total of six samples from the largest dump site found within each of the chosen study areas were taken for bacteriological analysis. The six chosen sampling sites provided a good representation in terms of the nature and constituents of typical waste dumps including evidence of faecal contamination as described in Chapter 1. The n = 36 samples taken were statistically significant based on similar previous studies that assessed and profiled microbial quality of waste dumps (Osunwoke and Kuforiji 2012: 59; Awisan *et al*. 2011: 30).

3.3.4 COLLECTION OF DATA

A total of n = 36 soil samples were collected from sub-surface contaminated soil from the chosen waste dumps.

3.3.4.1 Collection of contaminated soil specimens

Co-ordinate (latitude and longitude) readings were recorded at each of the largest waste dumps found at the time of sample collection within each study area. Soil samples were scooped from depths of 0-15cm and placed into sterile polyethylene screw type plastic sample bottles. Using a thermometer, the temperature of each sample was determined and recorded immediately after collection (Annexure I).

The first of the six samples (per dump site) was taken from an estimated central point in the chosen waste dump and thereafter the other five samples were taken at an equi-distance around the central point within the perimeter of the respective dump site, thus constituting a total of n = 6 samples per dump site. This was done to cater for spatial distribution of the *E. coli* isolates at each dumpsite.

The samples were protected from direct sunlight in an ice-packed hip cooler and was subsequently submitted to the Department of Microbiology Laboratory, UKZN, Westville Campus. Samples were stored at 4 °C until further microbiological analysis.

3.3.4.2 Microbiological analysis of contaminated soil samples

Figure 3.1 shows a complete flow chart of microbiological techniques and procedures utilized for the presumptive counts of *E.coli* in the soil samples, isolation and identification, and PCR detection of specific virulence genes for subsequent classification into the different DEC pathotypes.

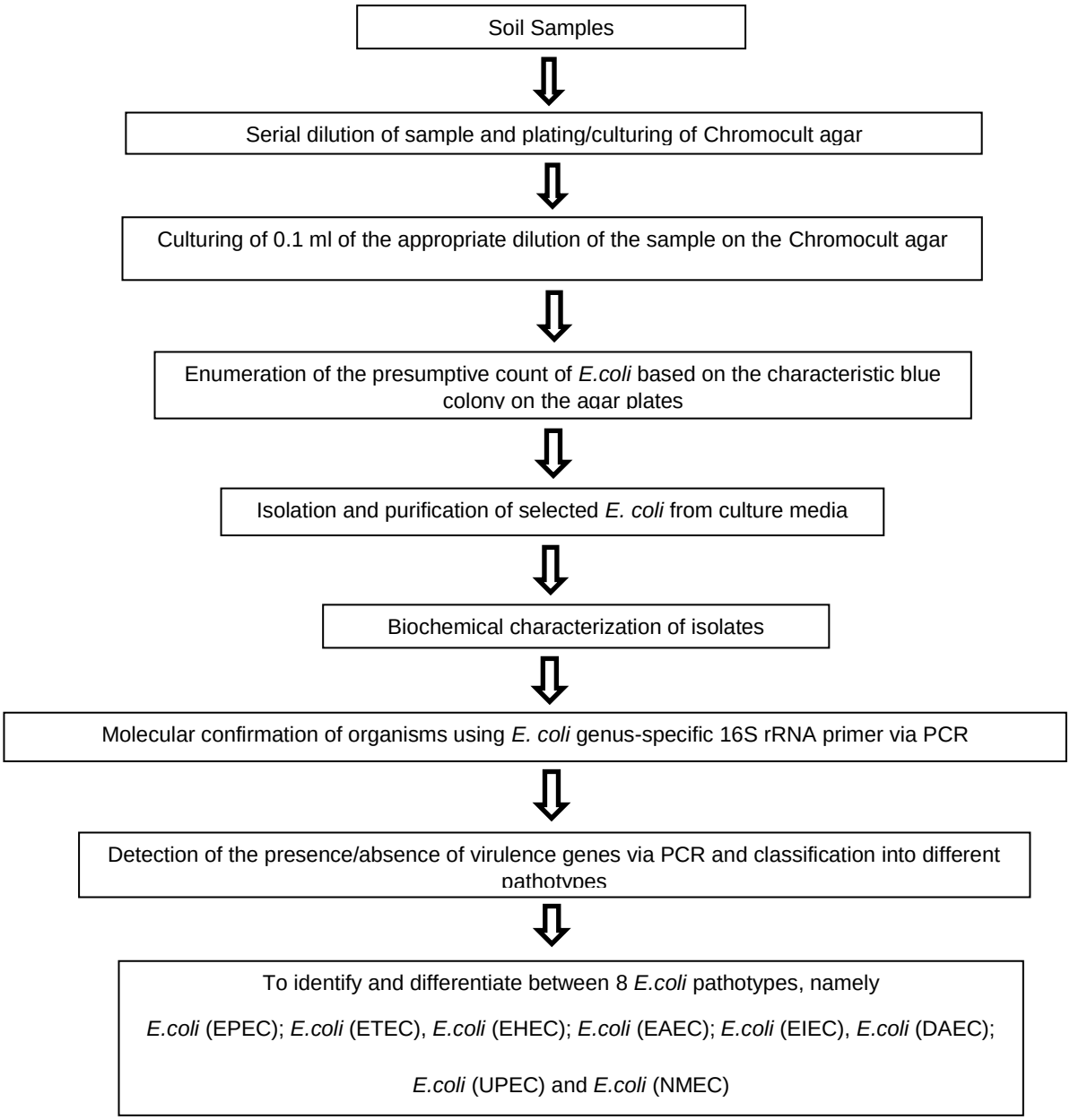

Figure 3.1: Microbiological laboratory procedures for presumptive enumeration, isolation and characterization of diarrhoeagenic *E.coli* from contaminated waste dump soil samples.

To evaluate whether DEC pathotypes are associated with the prevalence of childhood diarrhoea in the six settlements, it was necessary to take soil samples from domestic waste dumps, where children often played and test for the presence of pathogenic *E.coli* strains, including enterohaemorrhagic

E.coli (EHEC), enterotoxigenic *E.coli* (ETEC), enteropathogenic *E.coli* (EPEC), enteroaggregative *E.coli* (EAEC), enteroinvasive *E.coli* (EIEC), diffusely adherent *E.coli* (DAEC), uropathogenic *E.coli* (UPEC) and neonatal meningitis *E.coli* (NMEC), based on the distribution of the different virulence factors.

The detection and enumeration of *E.coli* populations in soil samples and subsequent PCR analysis of DEC pathotypes was performed as follows:

(i) Enumeration and isolation of presumptive *E.coli* isolates

Ten grams of each sample was added to 90 ml of sterile physiological saline solution, mixed vigorously by vortexing to allow for homogenization of the samples. Thereafter, 10-fold serial dilutions of the samples were made before plating 0.1 ml of the appropriate dilutions on Chromocult agar via spread plate technique. After incubation for 24 hours at 37^{o}C, presumptive *E.coli* with characteristic blue colonies on Chromocult agar were enumerated and expressed as Colony forming units per milliliter (CFU/ml). Subsequently, selected numbers of colonies per sample were subcultured on Chromocult agar and then purified by culturing on nutrient agar plates for 18-24 hours at 37^{o}C.

(ii) Presumptive bacterial identification

Gram stain was first performed on 18-24 hour cultures of the isolates to determine if the purified isolates were Gram negative/positive. Gram negative, non-spore forming rods were then identified using standard biochemical reactions (Clesceri, Greenberg and Strussell 1992).

The biochemical tests used for primary identification of the presumptive *E.coli* isolates, included, the triple sugar iron (TSI) slant test and the indole; methyl-red; Voges-Proskauer and the citrate utilization tests, all collectively known

as the IMViC test (Clesceri, Greenberg and Strussell 1992). Indole production test was performed by inoculating a 1% tryptone broth medium and incubation at 37ºC for 48 hours. The presence of indole was detected by the addition of 10 drops of Kovac's reagent to the medium. If indole was produced, it was extracted from the medium into the reagent layer by the acidified butanol component and formed a complex with ρ-dimethylaminobenzaldehyde, yielding a cherry red ring indicating a positive reaction. The methyl-red (MR) and Voges-Proskauer (VP) tests were performed simultaneously by inoculating MRVP broth medium and incubated at 37º for 48 hours.

Following the incubation period, one-third of the culture broth was aseptically transferred to a clean, sterilized test tube for the VP test. To detect glucose metabolism and subsequent production and stabilization of high concentration acid end products (MR), 5 drops of the methyl red pH indicator was added to the MR culture broth aliquot. The broth changes red (positive reaction) at a pH of 4 and yellow (negative reaction) at a pH of 6. To detect the production of non-acidic or neutral end products from the organic acids that result from glucose metabolism (VP), 10 drops of Barritt's A followed by 10 drops of Barritt's B solutions were added to the VP culture broth aliquot and shaken every 5 min with colour changes recorded after 15 min. Development of a deep rose colour of the broth was indicative of a positive reaction while no colour change was regarded as negative. Lastly, citrate utilization was detected by inoculation of Simmon's citrate agar slants, incubation at 37ºC for 48 hours and recording colour change of medium after the incubation period. A change in the colour of the slants from green to blue was taken as a positive result whereas no colour change in the medium was recorded as a negative reaction.

(iii) Molecular identification of biochemically identified *E. coli* isolates

The purified isolates were grown on nutrient agar at 37°C for 24 h, and afterwards 5 bacterial colonies were picked and transferred into 100 µL nuclease-free water in 1.5 mL Eppendorf tubes and homogenized by vortexing. The tubes were then placed in a heating bath at 100 °C for 10 min, after which, the tubes were centrifuged at 11 000 rpm for 3 min at 25 °C and immediately placed on ice (Sambrook and Russell, 2001). Supernatant was transferred into a new Eppendorf tube and used directly as DNA template for PCR assay. Primers specific for the *Mdh* gene of *E.coli* species (Table 3.2) were used in a 25 µL PCR reaction. PCR conditions were as follows: 94 °C for 3 min, 94 °C for 20 s, 60 °C for 30 s and 72 °C for 30 s, this was repeated for 30 cycles with the exception of the 72 °C elongation step; and a final extension phase of 72 °C for 5 min. *E.coli* reference strain ATCC 25922 was used as positive control while a reaction mixture containing nuclease-free water was used as a negative control (Wose Kinge *et al*., 2010). The amplified PCR products were analyzed by electrophoresis in 1.5 % (w/v) agarose gel at 60 V for 90 min in 1% TAE buffer. The products were visualized by UV transillumination (Syngene, UK) after staining in 0.1 mg/ml ethidium bromide for 15 min.

Table 3.2: List of primers used for the identification of *E.coli* and detection of the different virulence factors of *E.coli* in this study

Target	Primer Sequences 5'–3'	Amplicon size (bp)	References
E. coli spp.	CGTTCTGTTCAAATGGCCCTAGG ACTGAAAGGCAAACAGCCAAG	392	Wose Kinge *et al*. (2010)
fliC	AGC TGCAACGGTAAGTGATTT GGCAGCAAGCGGGTTGGTC	949	Bai *et al*. (2010)
stx1	TGTCGCATAGTGGAACCTCA TGCGCACTGAGAAGAAGAGA	655	Bai *et al*. (2010)
stx2	CCATGACAACGGACAGCAGTT TGTCGCCAGTTATCTGACATTC	477	Bai *et al*. (2010)
eae	CATTATGGAACGGCAGAGGT ACG GAT ATC GAA GCC ATT TG	375	Bai *et al*. (2010)
rfbE	CAG GTG AAG GTG GAA TGG TTG TC TTA GAA TTG AGA CCA TCC AAT AAG	296	Bai *et al*. (2010)
hlyA	GCG AGC TAA GCA GCT TGA AT	199	Bai *et al*. (2010)
lt	GCACACGGAGCTCCTCAGTC TCCTTCATCCTTTCAATGGCTTT	218	Obi *et al.* (2004)
st	AAAGGAGAGCTTCGTCACATTTT AATGTCCGTCTTGCGTTAGGAC	129	Vidal *et al*. (2004)
bfp	GGAAGTCAAATTCATGGGGGTAT GGAATCAGACGCAGACTGGTAGT	254	Vidal *et al*. (2004)
Agg	CTGGCGAAAGACTGAATCAT CAATGTATAGAAATCCGCTGTT	630	Obi *et al*. (2004)
cdtB	TAAATGGAATATACATGTCCG TTTCCAGCTACTGCATAATC	588	Hinenoya *et al.* (2014)
PapC	GACGGCTGTACTGCAGGGTGTGGCG ATATCCTTTCTGCAGGGATGCAATA	328	Caine *et al.* (2014)
EagR	AGACTCTGGCGAAAGACTGTATC ATGGCTGTCTGTAATAGATGAGAAC	194	Caine *et al.* (2014)
Ial	CTGGATGGTATGGTGAGG GGAGGCCAATTATTTCC	700	Caine *et al.* (2014)
IpaH	AGGTTAATCTTTGCAGGGCT CAACAACCAGCTTACTGCCT	423	Akhter *et al*. (2011)

The PCR reaction was done in a total volume of 25 µL and the following conditions (5 min at 94 °C, 25 cycles of 30 s at 94 °C, 30 s at 65 °C and 75 s at 68 °C and finally 7 min at 68 °C); *stx* gene and *bfp* gene (35 cycles, and each cycle consisted of 1.5 min at 94°C, 1.5 min at 64°C, and 1.5 min at 72°C), Agg gene (95°C for 5 min, 30 cycles of 94°C for 1 min 53°C for 1 min and 72°C for 1 min, and final extension of 72° for 10 min), PapC gene (An initial denaturation step at 94 °C for 5 min, followed by 36 cycles of 94 °C for 35 sec, annealing at 62 °C for 30 sec and elongation at 72 °C for 1 min. A final elongation step at 72 °C for 5 min), *Ial* gene (1 cycle for 2 min at 50 °C, 1 cycle for 5 min at 95 °C, 40 cycles for 45 sec at 95 °C, 45 sec at 55 °C and 45 sec at 72 °C and a final extension step for 10 min at 72 °C), *IpaH* gene (denaturation for 1 min at 94°C, annealing for 1 min at 55°C and extension at 72°C, for 1 minute. final extension of 10 min at 72°C), *EagR* (Initial denaturation at 95 °C for 15 min followed by 35 cycles of heat denaturation at 94 °C for 45 sec, primer annealing at 55 °C for 45 sec and DNA extension at 68 °C for 2 min. A final elongation step at 72 °C for 5 min), *cdtB* gene (Initial denaturation at 94 °C for 5 min followed by 35 cycles of heat denaturation at 94 °C for 30 s, primer annealing at 50 °C for 30 s and DNA extension at 72 °C for 1 min. A final elongation step at 72 °C for 5 min), *lt* gene (min denaturation at 95°C, 1 min at 60°C, and 1 min extension at 72°C; followed by a final extension step of 5 min at 72°C).

(iv) Molecular detection of virulence genes via monoplex and multiplex PCR

The DNA of the *E.coli* isolates was extracted as previously described in section (iii) following the method of Sambrook and Russell (2001). All strains were evaluated by multiplex PCR for identification of six virulence genes (*fliC, stx1, stx2, eae, rfbE, hlyA*). The set of primers used for the detection of virulence genes are shown in Table 3.2. The PCR reaction was done in a total volume of 25 µL and the following conditions (5 min at 94 °C, 25 cycles of 30 s at 94 °C, 30 s at 65 °C and 75 s at 68 °C and finally 7 min at 68 °C); *st* gene and *bfp* gene (35 cycles, and each cycle consisted of 1.5 min at 94°C, 1.5 min at 64°C, and 1.5 min at 72°C), *Agg* gene (95°C for 5 min, 30 cycles of 94°C for 1 min53°C for 1 min and 72°C for 1 min, and final extension of 72° for 10 min), *PapC* gene (An initial denaturation step at 94 °C for 5 min, followed by 36 cycles of 94 °C for 35 sec, annealing at 62 °C for 30 sec and elongation at 72 °C for 1 min. A final elongation step at 72 °C for 5 min), *Ial* gene (1 cycle for 2 min at 50 °C, 1 cycle for 5 min at 95 °C, 40 cycles for 45 sec at 95 °C, 45 sec at 55 °C and 45 sec at 72 °C and a final extension step for 10 min at 72 °C), *IpaH* gene (denaturation for 1 minute at 94°C, annealing for 1 minute at 55°C and extension at 72°C, for 1 minute. final extension of 10 min at 72°C), *EagR* (Initial denaturation at 95 °C for 15 min followed by 35 cycles of heat denaturation at 94 °C for 45 sec, primer annealing at 55 °C for 45 sec and DNA extension at 68 °C for 2 min. A final elongation step at 72 °C for 5 min), *cdtB* gene (Initial denaturation at 94 °C for 5 min followed by 35 cycles of heat denaturation at 94 °C for 30 s, primer annealing at 50 °C for 30 s and DNA extension at 72 °C for 1 min. A final elongation step at 72 °C for 5 min), *lt* gene (min denaturation at 95°C, 1 min at 60°C, and 1 min extension at 72°C; followed by a final extension step of 5 min at 72°C). Amplification products were analysed using 1.5% agarose gel electrophoresis in 1% TAE buffer at 60 V for 90 min. The products were visualized by UV illumination (Syngene, UK) after staining in 0.1 mg/ml ethidium bromide for 15 min.

A further literature review was performed to show health implications among under-five children including reservoirs, transmission routes and carriers of DEC namely EHEC, EPEC, ETEC and EAEC that were recovered from waste dumps in this study. Hence an evaluation of documented epidemiological studies will further support the significant role of these pathotypes in both epidemic and sporadic cases of acute diarrhoea in the under-five age group.

This chapter detailed the methodology employed to conduct both the KABP survey and soil sampling of waste dumps. The chapter that follows presents the results of this two-phased study.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

This chapter presents the results obtained in descriptive and inferential formats.

4.2 KABP SURVEY

In total, 360 questionnaires were administered to mothers and/or primary caregivers of children <5years of age and received a 100% response rate. The questionnaire was divided into 3 sections which measured various themes as illustrated below:

4.2.1 Socio-demographic characteristics of respondents

Demographic and household data inclusive of number of respondents per settlement, mothers and/or primary caregivers relationship to child, gender, age and nationality, length of stay in settlements, family size and number of children <5 years of the 360 respondents are presented in Table 4.1.

4.2.1.1 Gender, nationality and age distribution

Overall, 329 (91.4%) mothers, 30 (8.3%) fathers and 1 grandmother constituted the respondents that were interviewed for the study and 99.2% were South African citizens. The mean age of the respondents in each of the six study areas were as follows: Kennedy Rd (32 years), Foreman Road (31 years), Lacey Rd (33 years), Puntans Hill (27 years), Jadhu Place (28 years) and Burnwood (29 years).

4.2.1.2 Household and occupancy data

More than half of the respondents (59.9%) lived in their respective settlements for more than six years which included 30.4% of these residents living in their communities for more than 10 years. Most households had three occupants (47.5%) and 157 (43.6%) households comprised of four or more family members. Less than 9% of the households had two people living in them. The majority of households (96.9%) had one child between the ages of 0 to 4 years, ten households had two children between this age group and only one household having three children less than 5 years of age.

4.2.1.3 Employment and household income status

Nearly three-quarters of the respondents (76.7%) were unemployed. A total of 21.1% of the respondents were engaged in temporary or casual labour with only eight (2.2 %) having permanent employment. The above result is also reflected in the income ranges in the table below. Table 4.2 shows that nearly 46% of respondents reported monthly family incomes between R200-R500, with 13.9% below this range whilst 28.9% of respondents earned between R501-R1000 and 11.7% earning more than R1000 per month. Only two respondents reported that their monthly income was in excess of R3000 per month.

4.2.1.4 Level of education

Figure 4.1 graphically represent respondents' educational status. Overall, the majority of respondents (98.3%) reported that they attained some level of education while six (1.7%) of them were uneducated or illiterate. One hundred and thirty six (37.9%) respondents had a basic primary school education and 208 (57.9%) were educated to secondary level. Tertiary education was recorded for only nine (2.5%) of the respondents. On average,

64.9% of respondents had a secondary level of education whilst 28.8% had completed a primary school level of education.

Table 4.1: Socio-demographic characteristics of the study sample (n = 360) among the six chosen informal settlements

Statement		Location						Total
		Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road	
No. of respondents		n=49	n=52	n=98	n=115	n=22	n=24	N = 360
Respondents relationship to child	Mother	48	52	88	102	22	17	329
		98.0%	100.0%	89.8%	88.7%	100.0%	70.8%	91.4%
	Father	1	0	10	13	0	6	30
		2.0%	0.0%	10.2%	11.3%	0.0%	25.0%	8.3%
	Grandparent	0	0	0	0	0	1	1
		0.0%	0.0%	0.0%	0.0%	0.0%	4.2%	.3%
Gender	Male	1	0	10	13	0	6	30
		2.0%	0.0%	10.2%	11.3%	0.0%	25.0%	8.3%
	Female	48	52	88	102	22	18	330
		98.0%	100.0%	89.8%	88.7%	100.0%	75.0%	91.7%
Mean Age		28.7	28.1	31.3	32.3	27.7	32.9	30.7
Nationality:	Yes	46	52	98	115	22	24	357
		93.9%	100.0%	100.0%	100.0%	100.0%	100.0%	99.2%
	No	3	0	0	0	0	0	3
		6.1%	0.0%	0.0%	0.0%	0.0%	0.0%	.8%
No. of years living in settlement:	< 1 year	7	4	11	2	5	2	31
		14.3%	7.7%	11.2%	1.8%	22.7%	8.3%	8.6%
	1– 5 years	23	25	20	24	11	10	113
		46.9%	48.1%	20.4%	21.1%	50.0%	41.7%	31.5%
	6 – 10 years	9	18	32	37	3	7	106
		18.4%	34.6%	32.7%	32.5%	13.6%	29.2%	29.5%
	> 10 years	10	5	35	51	3	5	109
		20.4%	9.6%	35.7%	44.7%	13.6%	20.8%	30.4%
Family size:	2	11	2	6	6	4	3	32
		22.4%	3.8%	6.1%	5.2%	18.2%	12.5%	8.9%
	3	22	23	52	60	6	8	171
		44.9%	44.2%	53.1%	52.2%	27.3%	33.3%	47.5%
	4	7	18	16	32	7	9	89
		14.3%	34.6%	16.3%	27.8%	31.8%	37.5%	24.7%
	> 4	9	9	24	17	5	4	68
		18.4%	17.3%	24.5%	14.8%	22.7%	16.7%	18.9%
Children < 5 yrs per household	1.00	48	52	90	115	19	24	348
		98.0%	100.0%	92.8%	100.0%	86.4%	100.0%	96.9%
	2.00	1	0	6	0	3	0	10
		2.0%	0.0%	6.2%	0.0%	13.6%	0.0%	2.8%
	3.00	0	0	1	0	0	0	1
		0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	.3%

Table 4.2: Average monthly income per household

INCOME RANGE		Location						Total
		Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road	
What is the average monthly income in this household?	< R200	0	42	7	0	0	1	50
		0,0%	80,8%	7,1%	0,0%	0,0%	4,2%	13,9%
	R200 – R500	24	3	67	61	3	6	164
		49,0%	5,8%	68,4%	53,0%	13,6%	25,0%	45,6%
	R501 – R1000	11	0	23	53	8	9	104
		22,4%	0,0%	23,5%	46,1%	36,4%	37,5%	28,9%
	R1001 – R1500	5	6	1	1	7	8	28
		10,2%	11,5%	1,0%	,9%	31,8%	33,3%	7,8%
	R1501 – R2000	4	0	0	0	4	0	8
		8,2%	0,0%	0,0%	0,0%	18,2%	0,0%	2,2%
	R2001 – R3000	4	0	0	0	0	0	4
		8,2%	0,0%	0,0%	0,0%	0,0%	0,0%	1,1%
	> R3000	1	1	0	0	0	0	2
		2,0%	1,9%	0,0%	0,0%	0,0%	0,0%	,6%

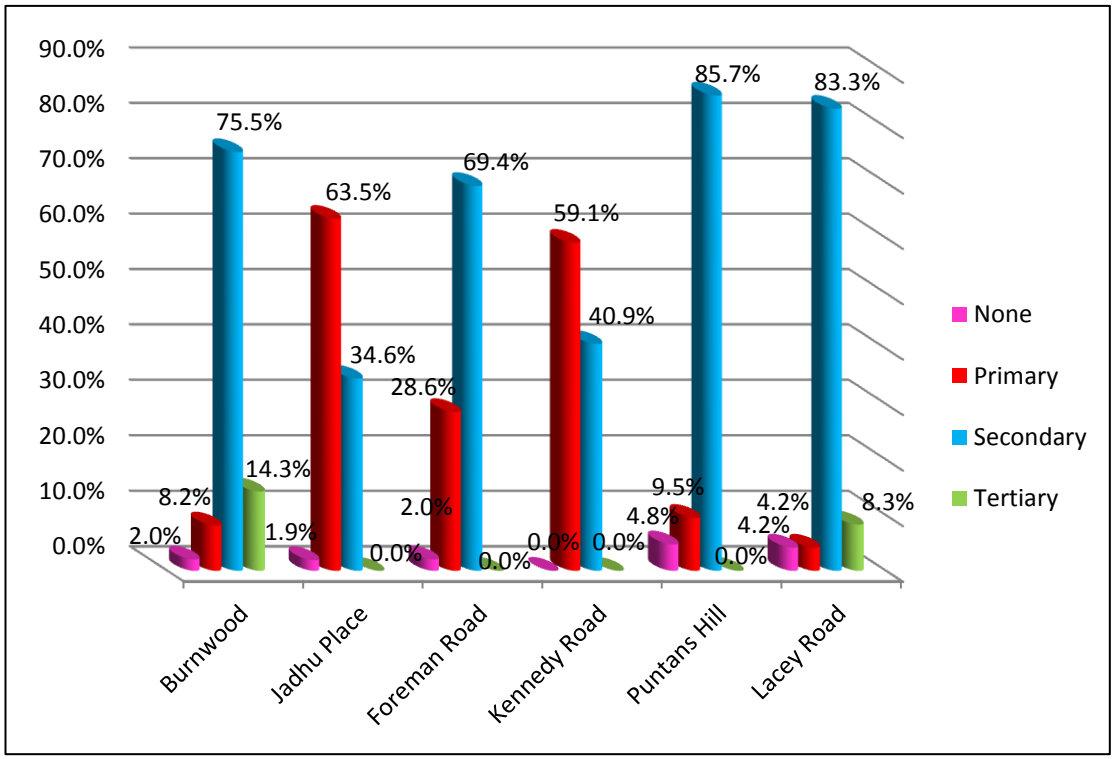

Figure 4.1: Education levels of n = 360 mothers and/or primary caregivers.

4.2.2 Mothers' and/or primary caregivers' knowledge, attitudes and practices towards domestic waste management, greywater disposal and sanitation methods

This section deals with the respondents' domestic waste management, greywater disposal and sanitation at household level within their respective communities.

According to Table 4.3, similar numbers of respondents opted for each of the three alternatives in respect to their knowledge of who collected waste from their settlement. A little more than half of the respondents (51.9%) identified waste removal once a week. More than a third, however, did not know the frequency of waste collection in their area. Overall, more than half of the 360 respondents (59%) indicated that they received either one, two or, more than two refuse bags on a weekly or monthly basis.

Table 4.3: Respondents' knowledge regarding waste management in their settlements

Statement		Location						Total
		Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road	
Do you know who collects waste in your settlement	DSW	20,4%	98,1%	11,2%	23,5%	100,0%	0,0%	33,6%
	Private Collector	77,6%	0,0%	51,0%	20,0%	0,0%	91,7%	36,9%
	Don't know	2,0%	1,9%	37,8%	56,5%	0,0%	8,3%	29,4%
How often is waste collected	Daily	0,0%	0,0%	0,0%	2,6%	0,0%	0,0%	,8%
	Weekly	95,9%	92,3%	32,7%	12,2%	100,0%	100,0%	51,9%
	Fortnightly	0,0%	0,0%	7,1%	21,7%	0,0%	0,0%	8,9%
	Don't know	4,1%	7,7%	60,2%	63,5%	0,0%	0,0%	38,3%
When are you allocated refuse bags	Weekly	22	48	32	12	21	24	159
		44,9%	92,3%	32,7%	10,4%	95,5%	100,0%	44,2%
	Monthly	20	0	3	30	1	0	54
		40,8%	0,0%	3,1%	26,1%	4,5%	0,0%	15,0%
	Don't receive	7	4	63	73	0	0	147
		14,3%	7,7%	64,3%	63,5%	0,0%	0,0%	40,8%
Percentage of respondents in receipt of refuse bags	1 Refuse Bag	45,2%	100,0%	69,7%	29,3%	36,4%	41,7%	57,1%
	2 Refuse Bags	23,8%	0,0%	18,2%	65,9%	63,6%	45,8%	32,4%
	More than 2 Refuse Bags	31,0%	0,0%	12,1%	4,9%	0,0%	12,5%	10,5%

Mothers' and/or primary caregivers' levels of education were assessed in terms of four knowledge, four practices and four attitude questions relating to waste management, domestic and greywater disposal and sanitation as shown in Tables 4.4, 4.5 and 4.6 below.

The chi-square statistical test was performed to evaluate mothers'and/or primary caregivers' level of education against their knowledge of waste management services within their settlements. Three of the four criteria as shown in Table 4.4 showed a significant positive association between their education levels and a basic understanding of current waste management practices ($P < 0.05$) overall across all six study areas but showed no substantial differences when calculated individually per settlement.

Table 4.4: Relationship between mothers'/primary caregivers' level of education and their knowledge of waste management within their settlements

Mothers/caregivers level of education and "Do you know who collects waste in your settlement?"	**P-value**	**0.000***
Mothers/caregivers level of education and "How often is the waste collected?"	**P-value**	**0.001***
Mothers/caregivers level of education and "When are you allocated refuse bags?"	P-value	0.105
Mothers/caregivers level of education and "If you are in receipt of bags, how many are you allocated**?"**	**P-value**	**0.002***

Table 4.5 shows no statistical or substantial differences between respondents' level of education and their attitudes or main reasons for indiscriminate dumping when the chi-square test was performed individually per settlement and overall inclusive of all six study areas.

Table 4.5: Relationship between mothers'/primary caregivers' level of education and their attitudes and reasons for discarding waste in their settlements

Mothers/caregivers level of education and their attitudes or reasons for disposing waste in their settlements (i.e. "Designated waste storage area situated far away from household" ; "Designated waste storage area is too dirty"; "Convenient and easy to throw into nearby waste dump" and "Everybody else in settlement does it"	P-value 0.193

When calculated collectively, the chi-square test showed no correlation between greywater disposal into waste dumps and mothers' and/or primary caregivers' education levels (*P* = 0.761) as shown in Table 4.6.

Table 4.6: Relationship between mothers'/primary caregivers' level of education and their practices related towards domestic waste management within their settlements

Mothers/caregivers level of education and "What do you do with the greywater after it has been used for bathing, cooking, cleaning and washing of items?	P-value 0.761
Mothers/caregivers level of education and "What type of toilet do you and the occupants of this household use every day?"	**P-value 0.000***
Mothers/caregivers level of education and "Do you throw your domestic waste in open waste dumps in the settlement?"	**P-value 0.002***
Mothers/caregivers level of education and "What type of toilet do your children use?"	P-value 0.123

The type of toilet or sanitation method used by mothers and/or primary caregivers and their families was statistically significant among the total number of respondents (n = 360) and their educational status but showed no association when calculated individually per locality. Figure 4.2 below shows the distribution of sanitation methods utilized by respondents and their families.

Overall, 56.1% of respondents have access to a communal flush toilet. The remaining toilet systems are pit latrines or associated with open defecation near waste dumps. In contrast, Figure 4.3 presents the under-five method of sanitation used within and across all six study areas.

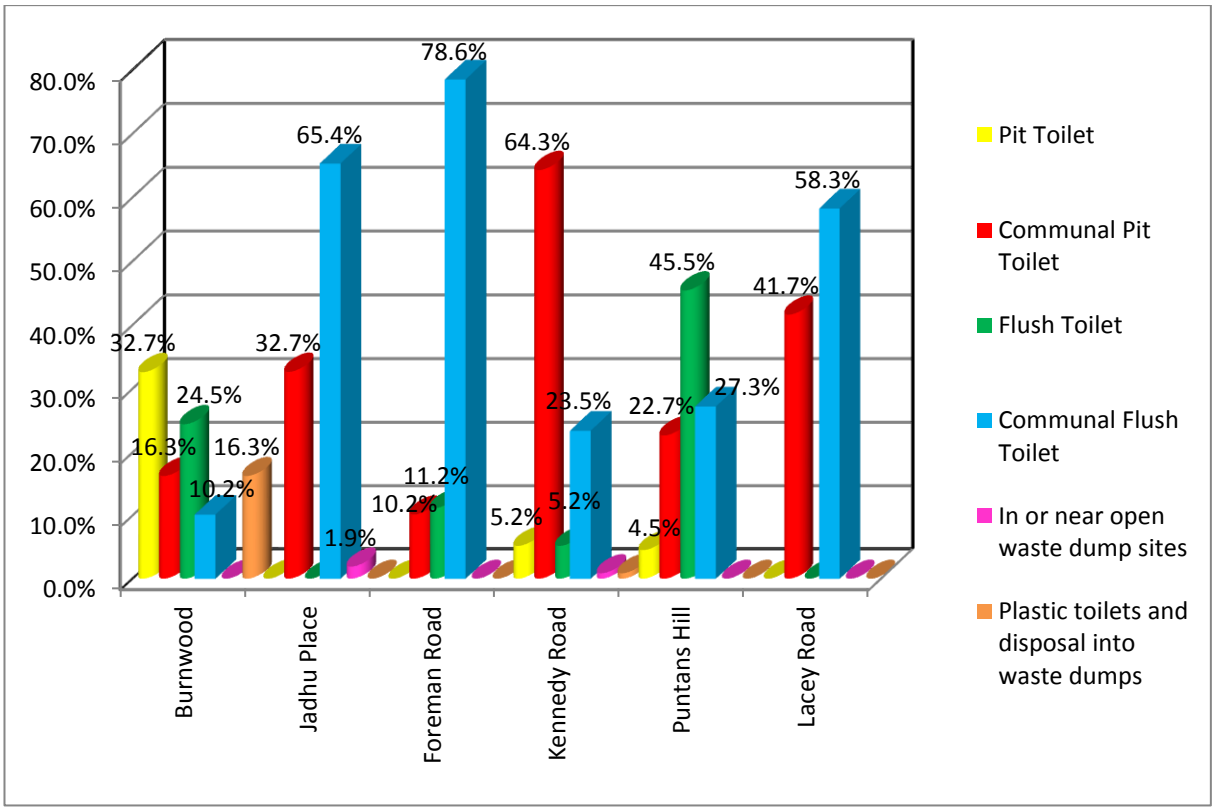

Figure 4.2: Type of toilet utilized by respondents.

According to Figure 4.3, almost 14% of children under-five openly defecated outside their households whist 23% and 32% utilized potties or diapers respectively. The remaining children utilized the same communal pit latrines or flush toilets utilized by adults within their settlements. Respondents were also asked to rate the ablution facilities (communal flush toilets) in terms of working in good order and being adequately maintained as shown in Figure 4.4 below.

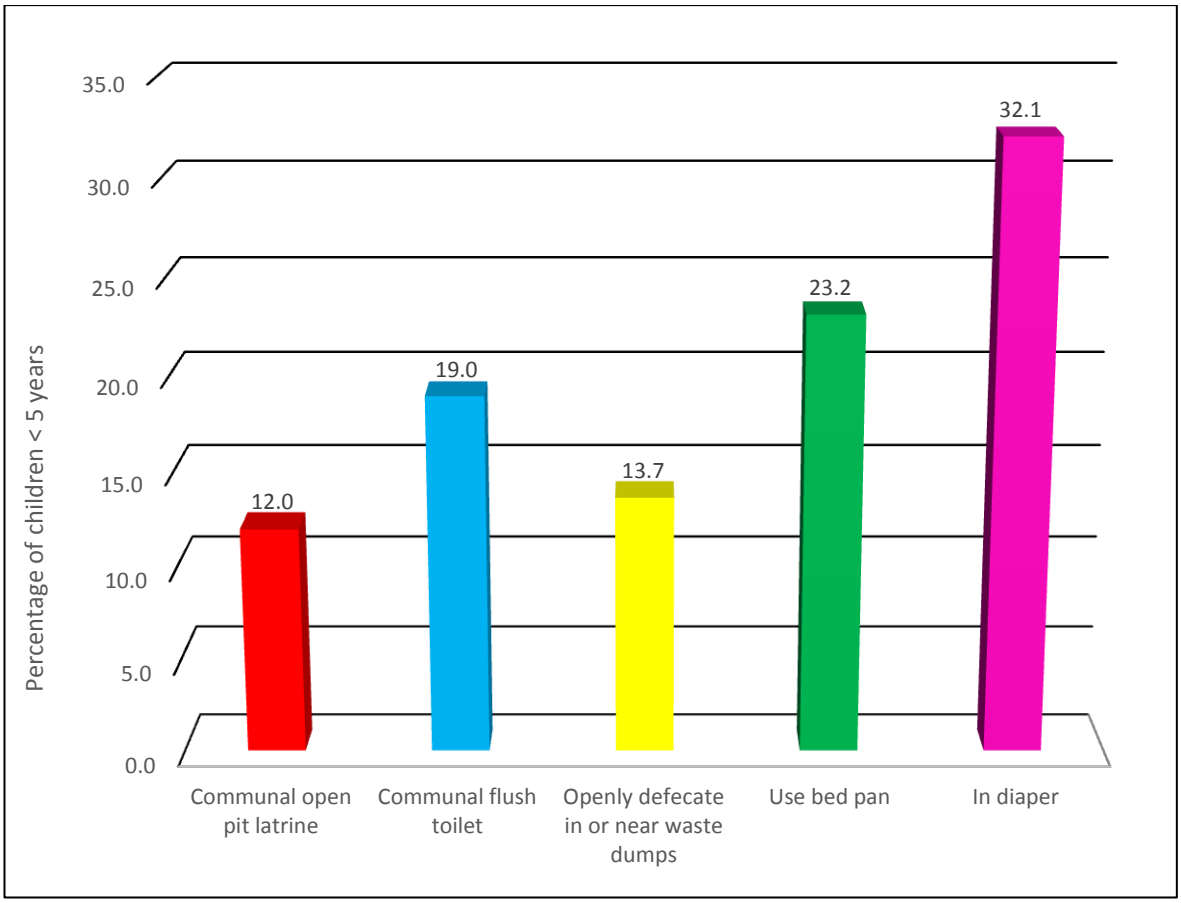

Figure 4.3: Type of toilet utilized by children (< 5 years of age).

Greater than three-quarters of the respondents (77.7%) disagreed that eThekwini ablution facilities are functional, well maintained and satisfy the needs of the community as indicated in Figure 4.4.

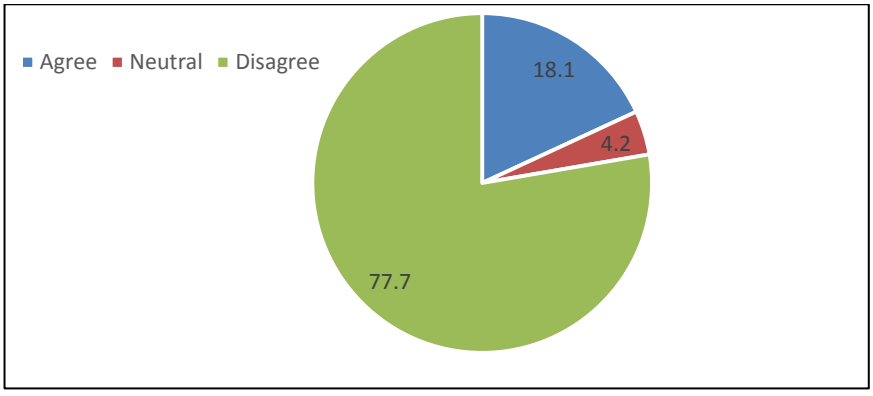

Figure 4.4: Respondents' feelings and opinions regarding the status of eThekwini Municipality managed ablution facilities.

The third practice, namely “Do they throw their domestic waste in open waste dumps in the settlement?” as listed in Table 4.6 also yielded overall, a positive correlation (*P* = 0.002) between mothers’ and/or primary caregivers’ educational level and those that discarded their waste into dumps but again showed no statistical difference when these two variables were calculatedly separately in each of the six chosen settlements.

Figures 4.5 and 4.6 below show graphical representations of the 360 respondents that either discarded or kept their refuse bags at identified pick-up points and the proximity of designated waste collection points for refuse removal, respectively within their settlements. Figure 4.5 shows that 63.2% of the respondents disposed of their everyday waste in a dump near their household, whilst 36.8% of respondents kept their refuse at a central collection point. It was also recorded that most residents (57.5%) had access to a central waste collection point nearby, i.e < 50 m away from their household whilst 42.5% indicated that the nearest temporary waste storage area was > 50 m away as depicted in Figure 4.6.

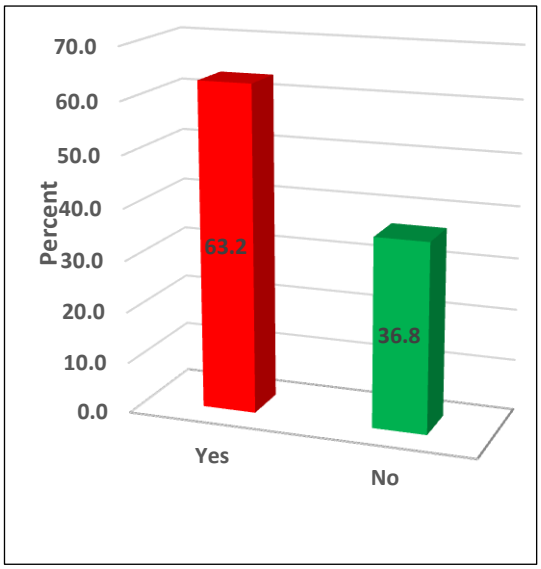

Figure 4.5: Percentage of respondents that discarded household waste into open waste dumps.

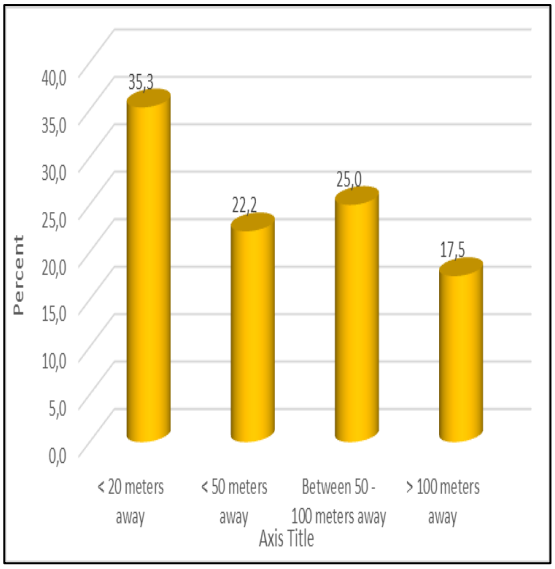

Figure 4.6: Proximity of designated waste collection points from households.

4.2.3 Children's exposure and risks associated with open waste dumps

Nearly 300 (80.8%) of respondents as shown in Figure 4.7 indicated that their children played in or near waste dumps. Thereafter, a Likert-scale statement namely, "Do you believe that children may be exposed to health and safety risks as a result of their indiscriminate dumping?" was probed to ascertain mothers' and/or primary caregivers' perceptions of potential risks to children as shown in Table 4.7 below.

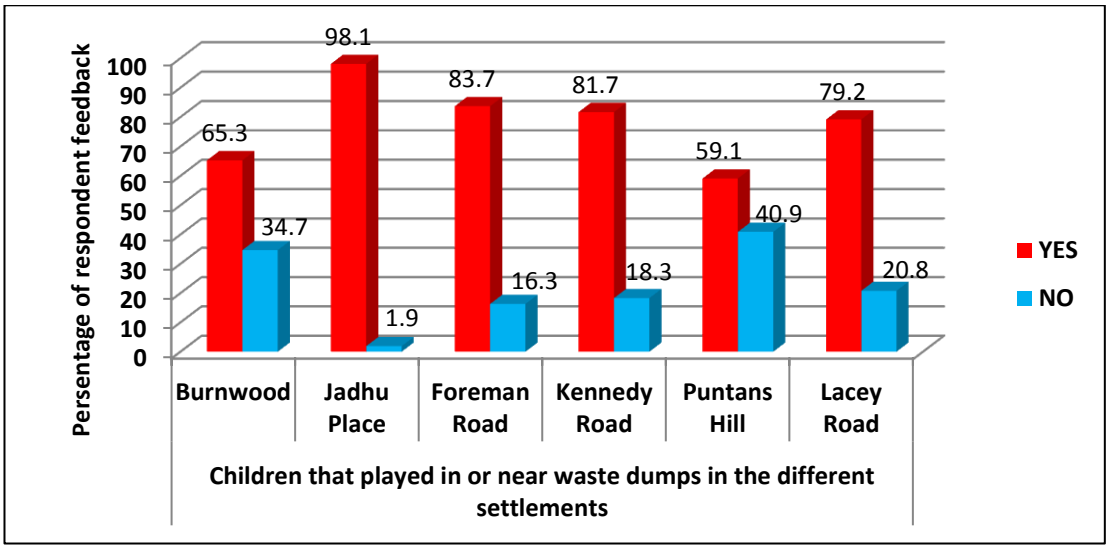

Figure 4.7: Number of respondents that indicated that their children play in or near waste dumps.

The significance of the statement in Table 4.7 was that 54% of the respondents agreed that waste dumps could cause health and safety hazards but 22% disagreed.

Table 4.7: Mothers'/primary caregivers' perceptions of whether their children may be exposed to health and safety risks whilst playing in or near waste dumps

	Yes/No	Percentage
Strongly agree	125	43%
Agree	32	11%
Neutral	70	24.1%
Disagree	37	12.7%
Strongly Disagree	27	9.3%
Total	291	100%

Table 4.8 shows the relationship between mothers and/or primary caregivers greywater and domestic waste disposal into open waste dumps including their family's sanitation methods and risks to children consequently caused by playing in or near these contaminated waste dump sites. A Fishers Exact Test performed on the three listed criteria clearly show that there is a significant association ($P < 0.05$) between children's exposure to waste as a result of these household practices across all study areas.

Table 4.8: Risks associated with children playing in or near waste dumps / and greywater disposal; domestic waste disposal; and types of toilets utilized by respondents and their families

Children playing in waste dumps/Greywater disposal into dumps	**P-value**	**0.008***
Children playing in waste dumps/Household waste discarded into dumps	**P-value**	**0.000***
Children playing in waste dumps/Toilets used by participants and their families	**P-value**	**0.014***

In addition Figure 4.8 below shows the risks associated with children playing in areas contaminated with human faeces. Two-thirds (66.9%) of the respondents indicated that children did play in and around such vicinities that have been used as toilet sites. This seems to be a common practice within all six study areas as depicted in Figure 4.8.

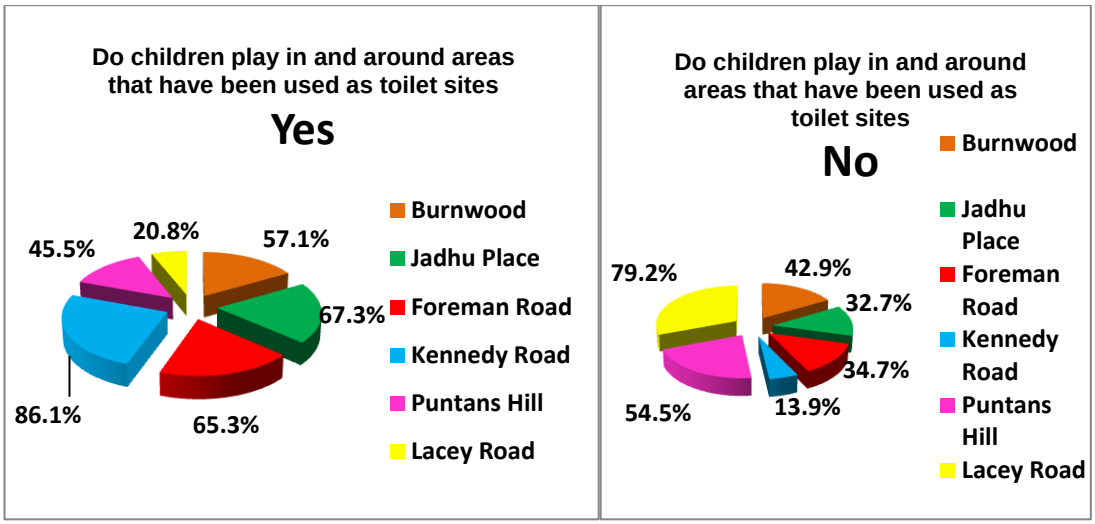

Figure 4.8: Percentage of children that played in and around areas that have been used as toilet sites.

4.2.4 Knowledge, attitudes, behaviour and practices regarding childhood diarrhoea

This section presents mothers' and/or primary caregivers' knowledge of childhood diarrhoea, practices related to its management, their attitudes and beliefs towards household hygiene practices and behaviour regarding risks associated with this illness.

4.2.4.1 Mothers'/primary caregivers' knowledge of childhood diarrhoea

Table 4.9 presents a summary of respondents' knowledge regarding the definition, severity, symptoms and causes of childhood diarrhoea. The majority of respondents (81.4%) defined diarrhoea as the passing of three or more unformed stools per day. Other descriptions of diarrhoea included abdominal pain (12.8%), nausea (5%), sunken eyes (22.5%) and children with blood in stools (8.3%). Table 4.9 shows that the majority of the respondents (88.6%) indicated that germs (bacterial infections) caused childhood diarrhoea and 34.4% mentioned that the illness was caused by dirty hands. Other reported causes included indigestible foods (4.4%), early

weaning (5%), worm infections (7.5%) and prolonged breastfeeding (1.1%) of their children. Many respondents (80.8%) believed that diarrhoea was a serious childhood illness.Two-thirds (66.9%) indicated that they had been educated about the signs, symptoms, modes of transmission and prevention of this childhood illness.

Table 4.9: Mothers'/primary caregivers' knowledge related to childhood diarrhoea

Statement			Location						Total	Overall Significance P Value < 0.05
			Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road		
Do you know what childhood diarrhoea is:		Yes	83.7%	100.0%	75.5%	100.0%	90.9%	100.0%	90.6%	0.12
		No	16.3%	0.0%	24.5%	0.0%	9.1%	0.0%	9.4%	
What are the symptoms of childhood diarrhoea:	Three or more unformed stools within a day	Yes	69.4%	88.5%	64.3%	97.4%	68.2%	95.8%	81.4%	**0.012***
		No	30.6%	11.5%	35.7%	2.6%	31.8%	4.2%	18.6%	
	Abdominal pain	Yes	18.4%	11.5%	12.2%	7.8%	18.2%	25.0%	12.8%	**0.040***
		No	81.6%	88.5%	87.8%	92.2%	81.8%	75.0%	87.2%	
	Cramps	Yes	6.1%	0.0%	2.0%	6.1%	4.5%	0.0%	3.6%	0.791
		No	93.9%	100.0%	98.0%	93.9%	95.5%	100.0%	96.4%	
	Nausea	Yes	10.2%	0.0%	3.1%	4.3%	9.1%	12.5%	5.0%	**0.010***
		No	89.8%	100.0%	96.9%	95.7%	90.9%	87.5%	95.0%	
	Vomiting	Yes	4.1%	0.0%	3.1%	2.6%	27.3%	4.2%	4.2%	0.055
		No	95.9%	100.0%	96.9%	97.4%	72.7%	95.8%	95.8%	
	Fever	Yes	4.1%	0.0%	2.0%	4.3%	13.6%	0.0%	3.3%	0.458
		No	95.9%	100.0%	98.0%	95.7%	86.4%	100.0%	96.7%	
	Sunken Eyes	Yes	63.3%	1.9%	2.0%	13.9%	36.4%	95.8%	22.5%	**0.000***
		No	36.7%	98.1%	98.0%	86.1%	63.6%	4.2%	77.5%	
	Blood in Stool	Yes	42.9%	0.0%	3.1%	0.0%	27.3%	0.0%	8.3%	**0.000***
		No	57.1%	100.0%	96.9%	100.0%	72.7%	100.0%	91.7%	
What do you think causes diarrhoea:	Germ / Bacterial infections	Yes	100.0%	100.0%	73.5%	90.4%	81.8%	100.0%	88.6%	0.568
		No	0.0%	0.0%	26.5%	9.6%	18.2%	0.0%	11.4%	
	Indigestible foods	Yes	4.1%	0.0%	3.1%	7.0%	9.1%	4.2%	4.4%	0.28
		No	95.9%	100.0%	96.9%	93.0%	90.9%	95.8%	95.6%	
	Early weaning	Yes	0.0%	0.0%	0.0%	15.7%	0.0%	0.0%	5.0%	0.075
		No	100.0%	100.0%	100.0%	84.3%	100.0%	100.0%	95.0%	
	Worm infection	Yes	6.1%	0.0%	1.0%	17.4%	13.6%	0.0%	7.5%	0.862
		No	93.9%	100.0%	99.0%	82.6%	86.4%	100.0%	92.5%	
	Dirty hands	Yes	67.3%	0.0%	43.9%	18.3%	68.2%	50.0%	34.4%	**0.001***
		No	32.7%	100.0%	56.1%	81.7%	31.8%	50.0%	65.6%	
	Prolonged breast feeding	Yes	0.0%	0.0%	0.0%	3.5%	0.0%	0.0%	1.1%	0.946
		No	100.0%	100.0%	100.0%	96.5%	100.0%	100.0%	98.9%	
Is diarrhoea a serious childhood illness:		Yes	81.6%	94.2%	86.7%	61.7%	100.0%	100.0%	80.8%	0.313
		No	18.4%	5.8%	13.3%	38.3%	0.0%	0.0%	19.2%	
Have you ever been educated about diarrhoea (signs, symptoms, modes of transmission, prevention)?		Yes	65.3%	98.1%	25.5%	75.7%	100.0%	100.0%	66.9%	0.725
		No	34.7%	1.9%	74.5%	24.3%	0.0%	0.0%	33.1%	

4.2.4.2 Mothers/primary caregivers attitudes towards hygiene practices and risks associated with childhood diarrhoea

This section looks at the respondents' attitudes and opinions of hygiene practices and their perceptions of risks related to contracting childhood diarrhoea.

Table 4.10 shows that the majority of respondents (93.6%) believed that childhood diarrhoea was in fact preventable. Eighty-eight percent indicated that proper washing of hands after coming into contact with their child's faecal matter can prevent this illness. Safe and hygienic disposal of faecal and domestic waste (41.1%) and hygienic food preparation (44.2%) were also reported ways in which the spread of childhood diarrhoea could be prevented.

Only 140 (39.2%) of respondents indicated that they wash their childrens' hands before they eat their meals. Fifty-six percent of children washed with soap and water whilst 43.8% used water only to wash their hands.

With respect to respondents' washing their own hands after toilet usage, assisting child in toilet, before feeding child and preparing food, the patterns are fairly consistent. Each of these four options has approximately the same value for the different activities. It is noted that hand washing among respondents is not usually practiced, with "sometimes" having the largest responses. All four options exacted a $P < 0.05$ which implies that the distributions were not similar, i.e., the differences between the way respondents scored (never, sometimes and usually) were significant.

Table 4.10: Respondents' attitudes relating to personal and domestic hygiene practices

Statement			Location						Total	Overall Significance P Value < 0.05
			Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road		
Do you think that diarrhoea is preventable:		Yes	95.9%	100.0%	96.9%	84.2%	100.0%	100.0%	93.6%	**0.012***
		No	4.1%	0.0%	3.1%	15.8%	0.0%	0.0%	6.4%	
How can diarrhoea be prevented:	Washing of hands with soap and water after getting in contact with a child's faecal matter:	Yes	98.0%	98.1%	90.8%	75.7%	95.5%	95.8%	88.6%	0.056
		No	2.0%	1.9%	9.2%	24.3%	4.5%	4.2%	11.4%	
	Safe and hygienic disposal of faecal and domestic refuse:	Yes	61.2%	1.9%	50.0%	25.2%	72.7%	95.8%	41.1%	**0.000***
		No	38.8%	98.1%	50.0%	74.8%	27.3%	4.2%	58.9%	
	Safe and hygienic food preparation:	Yes	75.5%	1.9%	59.2%	27.0%	36.4%	100.0%	44.2%	**0.000***
		No	24.5%	98.1%	40.8%	73.0%	63.6%	0.0%	55.8%	
Do you often wash the child's hands before eating:		Yes	67.3%	35.3%	48.0%	26.1%	35.0%	20.8%	39.2%	0.088
		No	32.7%	64.7%	52.0%	73.9%	65.0%	79.2%	60.8%	
How do you treat the child's hands before eating any food:		Washing with water only	3.0%	42.1%	42.6%	96.9%	37.5%	0.0%	43.8%	**0.001***
		Washing with water and soap	97.0%	57.9%	57.4%	3.1%	62.5%	100.0%	56.3%	
Do you often wash your hands:	After going to the toilet:	Never	0.0%	3.8%	4.1%	.9%	0.0%	100.0%	8.6%	**0.000***
		Sometimes	18.4%	80.8%	34.0%	83.5%	40.9%	0.0%	52.6%	
		Usually	81.6%	15.4%	61.9%	15.7%	59.1%	0.0%	38.7%	
	After helping your child defecate:	Never	0.0%	1.9%	3.1%	.9%	4.5%	100.0%	8.3%	**0.000***
		Sometimes	14.3%	78.8%	37.8%	83.5%	40.9%	0.0%	52.8%	
		Usually	85.7%	19.2%	59.2%	15.7%	54.5%	0.0%	38.9%	
	Before eating and feeding your child:	Never	0.0%	1.9%	4.1%	.9%	13.6%	100.0%	9.2%	**0.000***
		Sometimes	14.3%	80.8%	39.8%	83.5%	36.4%	0.0%	53.3%	
		Usually	85.7%	17.3%	56.1%	15.7%	50.0%	0.0%	37.5%	
	Before preparing food for your child:	Never	0.0%	1.9%	3.1%	12.2%	9.1%	100.0%	12.2%	**0.000***
		Sometimes	14.3%	78.8%	40.8%	72.2%	40.9%	0.0%	50.0%	
		Usually	85.7%	19.2%	56.1%	15.7%	50.0%	0.0%	37.8%	
Do you think that "no hand" washing after toilet usage, helping child defecate and before feeding and preparing food can spread diarrhoea:		Yes	77.6%	88.5%	51.0%	25.2%	72.7%	91.7%	55.8%	**0.004***
		No	22.4%	11.5%	49.0%	74.8%	27.3%	8.3%	44.2%	

The study also revealed mothers' and caregivers' attitudes and perceptions related to common pests and domestic pets as potential vectors of childhood diarrhoea as illustrated in Table 4.11.

In Table 4.11, 98.9% of respondents agreed that pests (flies, rats and cockroaches) did pose a health risk to their families. The types of pests identified by the respondents were as follows: flies (84.4%), mice/rats (84.2%) and cockroaches (57.8%). A significant correlation was recorded between flies, rodents and cockroaches and their presence in waste dumps ($P < 0.05$). Thereafter a Fishers Exact test was used to determine whether these three pests which were also found within their dwellings could pose a potential health risk to their families which confirmed a substantial positive correlation ($P = 0.000$).

Table 4.11 also shows that a small number (23%) of respondents owned pets including dogs, cats and poultry which were allowed to enter, rest or sleep within their households after knowing that they foraged through waste in the dump sites.

Table 4.11: Respondents' attitudes and perceptions of pets and pests as vectors of childhood diarrhoea

Statement			Location						Total	Overall Significance P Value < 0.05
			Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road		
Are there any pests (such as flies, rodents, cockroaches) that are seen in these waste dumps:		Yes	98.0%	100.0%	100.0%	100.0%	86.4%	100.0%	98.9%	**0.000***
		No	2.0%	0.0%	0.0%	0.0%	13.6%	0.0%	1.1%	
These pests pose a risk to the health and safety of your family:		Strongly Agree	83.7%	100.0%	76.5%	76.3%	81.0%	29.2%	77.9%	**0.000***
		Agree	14.3%	0.0%	23.5%	21.1%	9.5%	16.7%	16.8%	
		Neutral	2.0%	0.0%	0.0%	2.6%	9.5%	45.8%	4.7%	
		Disagree	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%	.3%	
		Strongly Disagree	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%	.3%	
What type of pests are found in and around your household:	Flies	Yes	95.9%	57.7%	84.7%	88.7%	81.8%	100.0%	84.4%	0.647
		No	4.1%	42.3%	15.3%	11.3%	18.2%	0.0%	15.6%	
	Rats	Yes	59.2%	96.2%	91.8%	97.4%	59.1%	37.5%	84.2%	**0.000***
		No	40.8%	3.8%	8.2%	2.6%	40.9%	62.5%	15.8%	
	Cockroaches	Yes	87.8%	7.7%	85.7%	44.3%	68.2%	45.8%	57.8%	**0.048***
		No	12.2%	92.3%	14.3%	55.7%	31.8%	54.2%	42.2%	
Do you own any of the following pets:		Dogs	76.5%	80.0%	81.5%	85.7%	33.3%	75.0%	77.6%	**0.000***
		Cats	11.8%	10.0%	7.4%	9.5%	50.0%	25.0%	12.9%	
		Poultry	11.8%	10.0%	11.1%	4.8%	16.7%	0.0%	9.4%	
Are these pets allowed to enter, rest or sleep within your household:		Yes	29.4%	50.0%	81.5%	95.0%	33.3%	100.0%	67.9%	**0.001***
		No	70.6%	50.0%	18.5%	5.0%	66.7%	0.0%	32.1%	
Do your pets or other residents' pets play in and around open waste dumps in your settlement:		Yes	55.1%	90.4%	29.6%	28.9%	90.9%	25.0%	45.1%	0.065
		No	44.9%	9.6%	70.4%	71.1%	9.1%	75.0%	54.9%	

In addition, Figure 4.9 shows that 43% of respondents agreed that pets could be a source of disease transmission with the scoring patterns being significantly different (*P* = 0.004). Figure 4.9 also shows that 27.3% of respondents disagreed that pets could be a source of disease transmission.

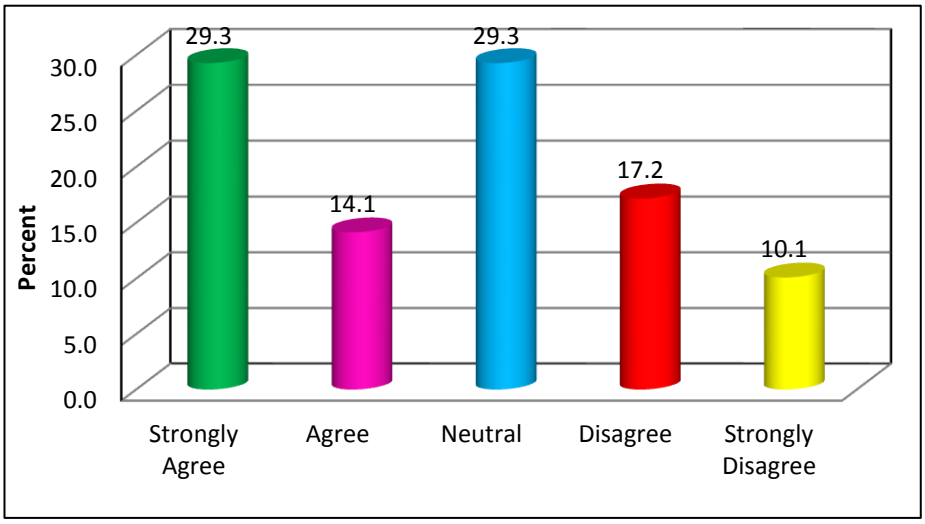

Figure 4.9: Respondents belief that pets can transmit disease among members of their household.

4.2.4.3 Mothers'/primary caregivers' practices towards childhood diarrhoeal treatment

This section looks at respondents' behaviour and practices when treating and nursing children with diarrhoea.

Eighty five percent of respondents reported that they visited the local PHC clinic when their child was ill with diarrhoea whilst 9.4% of them administered ready-made oral rehydration solutions (ORS). Eighty-six percent of mothers and/or primary caregivers administered homemade solutions which included a teaspoon of salt and eight teaspoons of sugar per litre of water during the period in which the child had diarrhoea. Twenty-seven percent of respondents indicated that they administered ORS to children with diarrhoea after every watery stool and similarly 30.4% reported a frequency of two -

three times per day whilst 35% indicated only when the child felt like drinking the rehydration solution. These three values are high whilst the remaining two options added to less than 8%.

Table 4.12: Respondents' practices towards childhood diarrhoeal management

Statement		Location						Total
		Burnwood	Jadhu Place	Foreman Road	Kennedy Road	Puntans Hill	Lacey Road	
What do you do when your child has diarrhoea:	Do nothing	0,0%	0,0%	0,0%	,9%	0,0%	0,0%	,3%
	Go to clinic	91,8%	76,9%	90,8%	90,4%	77,3%	50,0%	85,3%
	Go to (GP)	0,0%	0,0%	1,0%	1,7%	0,0%	0,0%	,8%
	Give oral rehydration solution (ready-made sachets)	6,1%	19,2%	7,1%	0,0%	18,2%	41,7%	9,4%
	Prepare and give home-made fluids	2,0%	1,9%	1,0%	6,1%	0,0%	4,2%	3,1%
	Use of traditional medicine	0,0%	1,9%	0,0%	,9%	4,5%	0,0%	,8%
	Go to traditional healer	0,0%	0,0%	0,0%	0,0%	0,0%	4,2%	,3%
Do you use homemade solutions when child has diarrhoea:	Yes	95,9%	96,2%	84,7%	87,7%	31,8%	87,5%	85,8%
	No	4,1%	3,8%	15,3%	12,3%	68,2%	12,5%	14,2%
If yes, how do you prepare it:	One teaspoon of salt, eight teaspoons of sugar in one litre of water	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
How often do you give oral rehydration solutions (ORS) to your child:	After every watery stool	34,0%	90,4%	1,2%	15,7%	18,2%	18,2%	26,7%
	Once a day	4,3%	1,9%	0,0%	17,6%	4,5%	4,5%	7,0%
	Two to three times a day	29,8%	3,8%	33,3%	32,4%	31,8%	72,7%	30,4%
	When the child wants to drink	31,9%	3,8%	65,5%	34,3%	31,8%	4,5%	35,0%
	Don't give child ORS	0,0%	0,0%	0,0%	0,0%	13,6%	0,0%	,9%

4.3 SAMPLING OF CONTAMINATED SOIL FROM SELECTED WASTE DUMPS

4.3.1 Isolation and identification of environmental *E. coli* strains

Table 4.13 shows the presumptive *E.coli* count per sample taken from each waste dump (i.e. six samples extracted per largest waste dump in each of the 6 study settlements). A total of 400 isolates were subsequently taken from n = 36 samples and 325 of these were identified as *E.coli* strains, based on several presumptive and confirmatory tests, as indicated in Figure 4.10.

Table 4.13: Presumptive *E.coli* counts of the 6 settlement waste dump sites

Name of Informal Settlement	Sample Number	*E.coli* count per sample (Cfu/ml)
Burnwood	B1	54000
	B2	110000
	B3	26000
	B4	198000
	B5	96666.67
	B6	170666.7
Foreman Road	FR1	10500
	FR2	210000
	FR3	100000
	FR4	20000
	FR5	48000
	FR6	8500
Jadhu Place	JP1	2100000
	JP2	840000
	JP3	680000
	JP4	284000
	JP5	184000
	JP6	1508000
Kennedy Road	KR1	200666.7
	KR2	4000
	KR3	59000
	KR4	13000
	KR5	6400
	KR6	78350
Lacey Road	LR1	53000
	LR2	103666.7
	LR3	235333.3
	LR4	8000
	LR5	170666.7
	LR6	64000
Puntans Hill	PH1	143000
	PH2	154333.3
	PH3	95000
	PH4	174000
	PH5	331000
	PH6	650000

4.3.2 Molecular identification *E. coli* spp. Isolates

Of the 400 isolates extracted from n = 36 soil samples, 325 isolates were identified to belong to the *E.coli* species based on the PCR detection of the conserved *Mdh* gene in *E.coli*.

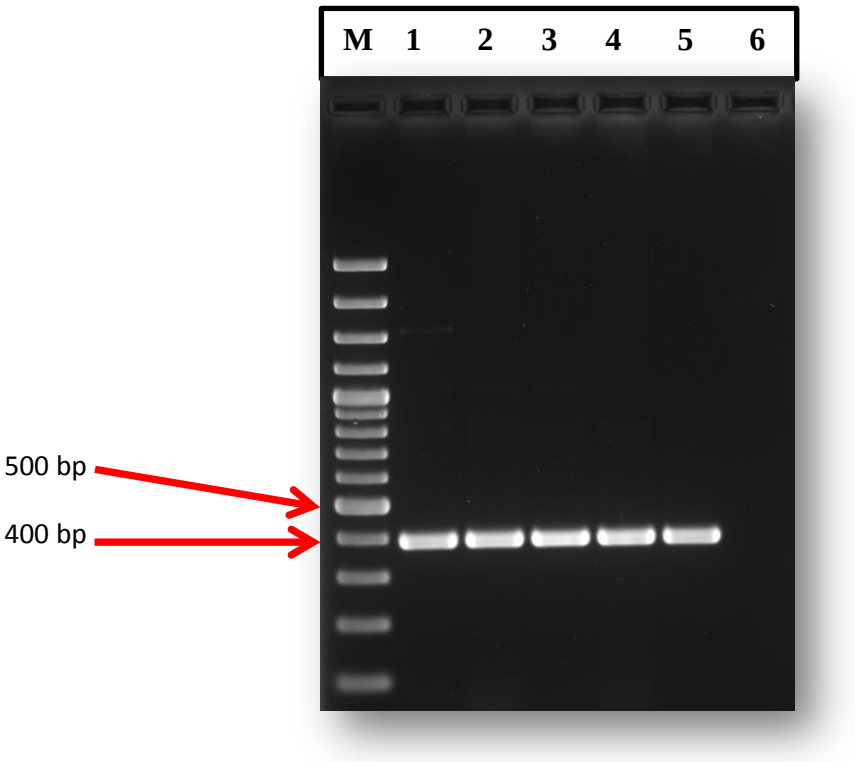

Figure 4.10: Agarose gel showing the expected amplicon size of *mdh gene* (392 bp) in *E.coli* species. Lane M contains 1 kb plus marker, lane 1 contains the positive control and lane 2 to 5 contains positive isolates and lane 6 contains the negative control.

A total of n = 56; n = 41; n = 66; n = 53; n = 51 and n = 58 *E.coli* isolates were positively identified in waste dumps located in the Burnwood, Foreman Road, Jadhu Place, Kennedy Road, Lacey Road, Puntans Hill and Foreman Road informal settlements respectively.

Table 4.14: Virulence gene detection of n = 325 *E.coli* isolates

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*lt*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*lpaH*	*EagR*
B 1	+	+	-	-	+	-	-	+	+	-	-	-	-	-	-
B 1 (10)	+	-	-	+	+	+	-	+	-	-	-	+	-	-	-
B 1 (11)	+	+	+	-	-	-	-	+	-	+	-	-	-	-	-
B 1 (2)	-	-	-	+	-	-	+	-	+	-	+	+	-	-	-
B 1 (3)	-	-	+	-	+	+	-	+	+	-	-	+	-	-	-
B 1 (4)	-	+	-	+	-	+	-	-	-	+	-	-	-	-	-
B 1 (5)	-	-	+	-	-	+	-	+	-	+	+	+	-	-	-
B 1 (8)	-	+	+	+	-	+	+	-	+	-	-	-	-	-	-
B 1 (9)	-	-	+	+	+	+	-	-	-	-	+	+	-	-	-
B 2 (10)	-	+	+	+	-	-	-	-	+	-	-	-	-	-	-
B 2 (11)	-	-	-	+	+	-	-	+	-	-	-	+	-	-	-
B 2 (12)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
B 2 (2)	-	+	+	+	-	-	+	+	-	-	-	-	-	-	-
B 2 (3)	-	+	+	+	+	-	-	-	+	-	+	-	-	-	-
B 2 (4)	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-
B 2 (5)	-	-	+	-	+	-	-	-	+	-	-	-	-	-	-
B 2 (6)	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
B 2 (7)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
B 2 (8)	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-
B 2 (9)	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-
B 3 (10)	-	+	+	+	-	+	-	+	-	+	-	-	-	-	-
B 3 (11)	+	+	-	+	-	+	-	+	+	+	-	-	-	-	-
B 3 (12)	-	+	+	-	-	+	-	-	-	+	+	-	-	-	-
B 3 (4)	-	-	+	+	+	+	-	+	-	-	-	-	-	-	-
B 3 (5)	-	-	+	-	-	+	+	-	+	-	-	-	-	-	-
B 3 (6)	-	+	+	-	-	-	-	-	-	-	+	+	-	-	-
B 3 (7)	-	-	-	+	+	-	-	+	+	-	-	-	-	-	-
B 3 (8)	-	-	+	-	-	-	-	+	-	-	-	+	-	-	-
B 3 (9)	+	+	-	+	+	-	-	+	-	-	-	+	-	-	-
B 4 (10)	-	-	+	-	-	+	-	-	+	-	-	+	-	-	-
B 4 (11)	-	+	+	+	-	-	-	-	+	-	+	+	-	-	-
B 4 (12)	+	+	+	+	+	-	+	+	+	-	-	-	-	-	-
B 4 (2)	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-
B 4 (4)	-	-	+	+	-	-	-	+	+	-	-	+	-	-	-
B 4 (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B 4 (9)	-	-	-	+	+	-	-	+	+	-	+	-	-	-	-
B 5 (10)	-	+	+	-	+	+	+	+	-	-	-	+	-	-	-
B 5 (11)	-	-	-	+	-	-	-	+	+	-	-	+	-	-	-
B 5 (12)	+	-	+	+	+	-	-	-	-	+	-	-	-	-	-
B 5 (2)	-	-	+	+	-	-	-	-	+	-	+	-	-	-	-
B 5 (3)	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-
B 5 (4)	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-
B 5 (5)	-	+	+	-	+	-	-	-	-	-	-	+	-	-	-
B 5 (6)	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-
B 5 (7)	-	-	+	+	-	+	+	-	+	-	-	+	-	-	-
B 5 (8)	-	+	-	-	+	-	-	-	+	-	-	-	-	-	-
B 6 (10)	+	-	+	+	-	-	-	+	+	-	-	+	-	-	-
B 6 (11)	-	-	-	+	+	+	-	-	+	-	-	-	-	-	-
B 6 (12)	+	-	-	+	-	-	-	+	-	-	-	+	-	-	-
B 6 (2)	+	+	+	+	-	-	-	-	-	-	+	-	-	-	-
B 6 (3)	+	-	+	-	-	-	-	-	-	+	-	+	-	-	-
B 6 (5)	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-
B 6 (6)	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-
B 6 (7)	+	+	-	+	+	-	-	-	+	+	-	+	-	-	-
B 6 (8)	-	-	+	-	-	+	-	+	-	-	+	-	-	-	-
B 6 (9)	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-
FR 1 (1)	-	+	-	-	+	-	+	+	-	-	-	-	-	-	-

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*lt*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*lpaH*	*EagR*
FR 1 (10)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
FR 1 (11)	-	+	+	+	+	-	-	+	-	-	-	-	-	-	-
FR 1 (12)	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-
FR 1 (2)	-	-	-	+	-	+	-	-	+	-	-	+	-	-	-
FR 1 (3)	-	+	+	-	+	-	-	+	-	+	-	-	-	-	-
FR 1 (4)	-	+	+	+	-	-	-	-	-	-	-	+	-	-	-
FR 1 (5)	-	+	-	+	-	+	+	-	-	-	-	-	-	-	-
FR 1 (6)	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
FR 1 (7)	-	-	+	-	-	+	-	+	-	-	-	+	-	-	-
FR 1 (8)	+	+	+	-	-	+	-	-	+	+	-	+	-	-	-
FR 1 (9)	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
FR 3	+	-	-	+	+	-	-	+	-	+	-	-	-	-	-
FR 3 (1)	-	-	+	-	-	+	-	-	-	-	+	-	-	-	-
FR 3 (12)	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-
FR 3 (2)	+	+	-	+	+	+	+	-	-	-	-	-	-	-	-
FR 3 (3)	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-
FR 3 (4)	-	-	+	-	+	+	-	+	-	-	-	-	-	-	-
FR 3 (5)	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-
FR 3 (6)	-	-	+	+	+	+	-	-	-	-	-	+	-	-	-
FR 3 (7)	-	+	-	+	+	+	-	+	-	-	+	-	-	-	-
FR 3 (8)	+	-	+	-	+	+	-	-	-	-	-	-	-	-	-
FR 3 (9)	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-
FR 4	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
FR 5 (2)	-	-	+	+	+	+	-	+	-	-	+	-	-	-	-
FR 5 (3)	+	+	-	-	+	+	-	-	-	-	-	-	-	-	-
FR 5 (4)	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-
FR 5 (5)	-	+	-	-	+	+	-	-	-	+	-	-	-	-	-
FR 5 (6)	-	-	+	+	-	+	-	-	-	-	-	+	-	-	-
FR 6	-	-	+	+	+	-	-	-	-	-	+	-	-	-	-
FR 6 (10)	-	+	+	-	-	-	+	+	-	+	-	-	-	-	-
FR 6 (11)	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
FR 6 (12)	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-
FR 6 (2)	+	-	+	-	+	-	-	+	-	-	-	+	-	-	-
FR 6 (3)	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-
FR 6 (4)	+	+	+	+	-	-	-	-	-	+	-	-	-	-	-
FR 6 (5)	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-
FR 6 (6)	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-
FR 6 (7)	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
FR 6 (8)	-	-	+	+	-	-	+	+	-	-	-	+	-	-	-
FR 6 (9)	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
JP 1	-	+	+	+	+	+	-	-	-	-	-	+	-	-	-
JP 1 (10)	-	+	-	-	-	-	+	-	-	-	-	+	-	-	-
JP 1 (11)	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
JP 1 (12)	+	-	-	+	+	+	-	-	-	-	-	+	-	-	-
JP 1 (2)	-	+	+	+	-	+	-	-	-	-	-	+	-	-	-
JP 1 (3)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
JP 1 (4)	+	-	-	+	+	-	+	+	-	+	+	+	-	-	-
JP 1 (5)	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-
JP 1 (6)	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
JP 1 (7)	-	+	+	+	-	-	-	+	-	-	-	-	-	-	-
JP 1 (8)	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-
JP 1 (9)	+	+	+	+	+	-	-	-	-	-	-	+	-	-	-
JP 2	-	-	+	+	-	+	-	-	-	+	-	+	-	-	-
JP 2 (10)	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-
JP 2 (11)	-	+	-	-	-	+	-	+	-	-	-	-	-	-	-
JP 2 (12)	-	+	+	+	+	+	-	+	-	-	-	+	-	-	-
JP 2 (2)	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-
JP 2 (3)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
JP 2 (4)	-	-	-	+	+	+	-	-	-	-	-	+	-	-	-

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*lt*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*lpaH*	*EagR*
JP 2 (5)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
JP 2 (6)	+	-	+	-	+	+	-	+	-	+	-	-	-	-	-
JP 2 (7)	-	+	-	-	-	-	-	-	+	-	-	+	-	-	-
JP 2 (8)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
JP 2 (9)	-	-	+	+	+	-	-	-	+	-	-	+	-	-	-
JP 3 (10)	+	+	-	-	-	+	-	+	-	-	-	-	-	-	-
JP 3 (11)	+	-	-	-	-	-	-	+	-	+	-	-	-	-	-
JP 3 (12)	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
JP 3 (2)	-	+	+	-	-	+	+	-	+	-	-	+	-	-	-
JP 3 (3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JP 3 (4)	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
JP 3 (5)	-	-	+	+	-	+	-	-	-	+	-	+	-	-	-
JP 3 (6)	+	-	-	-	+	-	+	-	+	-	-	-	-	-	-
JP 3 (7)	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
JP 3 (8)	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
JP 3 (9)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
JP 4	-	-	-	+	-	+	-	+	-	-	-	+	-	-	-
JP 4 (1)	+	+	-	-	-	-	+	-	-	+	-	-	-	-	-
JP 4 (2)	-	-	-	+	-	-	-		+	-	-	-	-	-	-
JP 4 (3)	-	+	-	-	+	-	-	+	-	-	-	+	-	-	-
JP 4 (4)	-	-	+	+	-	+	-	-	-	+	-	-	-	-	-
JP 4 (6)	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
JP 4 (7)	-	+	-	-	-	+	-	+	-	-	-	-	-	-	-
JP 4 (8)	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-
JP 4 (9)	-	+	-	+	-	-	-	-	-	-	-	+	-	-	-
JP 5 (10)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
JP 5 (12)	-	+	+	-	-	+	+	-	-	-	-	-	-	-	-
JP 5 (2)	+	+	-	+	-	-	-	-	-	+	-	+	-	-	-
JP 5 (2)	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
JP 5 (3)	-	-	+	+	+	-	-	-	+	-	-	-	-	-	-
JP 5 (4)	+	-	-	-	-	+	+	+	-	+	-	+	-	-	-
JP 5 (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JP 5 (6)	-	+	-	+	+	-	-	-	+	-	-	-	-	-	-
JP 5 (7)	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
JP 5 (8)	+	+	-	+	-	-	-	-	+	-	-	+	-	-	-
JP 5 (9)	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
JP 6	-	-	-	+	-	+	-	+	+	-	-	-	-	-	-
JP 6 (11)	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
JP 6 (12)	+	-	-	-	-	+	-	+	+	+	-	-	-	-	-
JP 6 (3)	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-
JP 6 (4)	-	+	-	+	+	-	+	-	+	-	-	+	-	-	-
JP 6 (5)	-	-	-	-	-	-	+	+	-	+	-	-	-	-	-
JP 6 (6)	+	+	-	+	-	+	-	-	+	-	-	-	-	-	-
JP 6 (7)	-	-	+	+	-	+	-	-	+	-	-	-	-	-	-
JP 6 (8)	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
JP 6 (9)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 1	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-
KR 1 (10)	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-
KR 1 (11)	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-
KR 1 (12)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 1 (3)	+	-	+	-	+	-	-	+	-	-	-	-	-	-	-
KR 1 (4)	-	+	-	+	-	+	+	-	-	-	-	-	-	-	-
KR 1 (5)	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
KR 1 (6)	-	-	-	-	+	+	-	+	-	-	-	-	-	-	-
KR 1 (7)	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
KR 1 (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KR 1 (9)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 2 (10)	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-
KR 2 (11)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*lt*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*lpaH*	*EagR*
KR 2 (12)	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-
KR 2 (2)	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
KR 2 (3)	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
KR 2 (4)	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
KR 2 (5)	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KR 2 (7)	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
KR 2 (8)	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
KR 2 (9)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
KR 3 (10)	+	+	-	+	+	+	-	-	-	+	-	-	-	-	-
KR 3 (11)	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
KR 3 (12)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
KR 3 (2)	-	+	+	+	-	+	-	+	-	+	-	-	-	-	-
KR 3 (3)	-	-	+	-	+	-	-	+	-	-	-	-	-	-	-
KR 3 (4)	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 3 (5)	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-
KR 3 (6)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
KR 3 (7)	-	+	+	+	+	+	-	+	-	-	-	-	-	-	-
KR 3 (8)	+	-	+	+	-	-	-	+	-	-	-	+	-	-	-
KR 3 (9)	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
KR 4	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
KR 4 (10)	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-
KR 4 (12)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
KR 4 (3)	-	-	-	+	-	+	-	-	-	+	-	+	-	-	-
KR 4 (4)	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 4 (5)	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-
KR 4 (6)	-	-	+	+	-	-	-	+	-	-	-	+	-	-	-
KR 4 (7)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
KR 4 (8)	-	-	-	-	+	+	-	+	-	-	-	-	-	-	-
KR 4 (9)	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-
KR 6	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-
KR 6 (10)	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
KR 6 (11)	-	+	+	-	+	+	-	-	-	-	-	+	-	-	-
KR 6 (12)	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
KR 6 (2)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
KR 6 (3)	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
KR 6 (5)	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-
KR 6 (6)	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
KR 6 (7)	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
KR 6 (8)	+	-	+	+	-	-	-	+	-	-	-	-	-	-	-
KR 6 (9)	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-
LR 1 (8)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
LR 1 (10)	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-
LR 1 (11)	-	+	+	+	-	-	-	+	-	-	-	-	-	-	-
LR 1 (12)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
LR 1 (2)	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-
LR 1 (3)	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-
LR 1 (4)	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-
LR 1 (5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR 1 (6)	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-
LR 1 (7)	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-
LR 1 (8)	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
LR 1 (9)	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-
LR 2 (2)	+	-	+	+	+	-	-	+	-	+	-	-	-	-	-
LR 2 (3)	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-
LR 2 (4)	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-
LR 2 (5)	+	+	+	-	-	+	-	+	+	-	-	-	-	-	-
LR 2 (6)	-	+	-	+	-	-	-	+	+	-	-	-	-	-	-
LR 2 (7)	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-
LR 2 (8)	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*lt*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*lpaH*	*EagR*
LR 3	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-
LR 3 (1)	-	-	+	+	-	+	-	-	+	-	-	-	-	-	-
LR 3 (10)	-	+	-	+	+	-	-		+	-	-	-	-	-	-
LR 3 (11)	-	-	+	-	-	-	-	+	+	+	-	-	-	-	-
LR 3 (12)	-	+	+	+	-	-	-	+	+	-	-	-	-	-	-
LR 3 (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR 3 (4)	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-
LR 3 (6)	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-
LR 3 (7)	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-
LR 3 (8)	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-
LR 3 (9)	-	+	+	+	+	-	-	+	-	-	-	-	-	-	-
LR 4	+	-	+	+	-	-	-	+	-	-	-	-	-	-	-
LR 4 (10)	-	+	+	+	-	-	-	-	+	-	-	-	-	-	-
LR 4 (11)	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
LR 4 (12)	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
LR 4 (2)	-	+	+	+	+	-	-	+	-	+	-	-	-	-	-
LR 4 (3)	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-
LR 4 (4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR 4 (6)	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-
LR 4 (7)	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-
LR 4 (8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR 4 (9)	-	+	+	+	-	+	-	+	-	+	-	-	-	-	-
LR 5 (1)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
LR 6	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
LR 6 (10)	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
LR 6 (12)	-	-	-	+	+	-	-	+	-	+	-	-	-	-	-
LR 6 (2)	-	+	+	+	-	-	-	+	+	-	-	-	-	-	-
LR 6 (3)	-	-	+	-	-	+	+	-	-	+	-	-	-	-	-
LR 6 (5)	-	+	+	+	-	-	-	+	+	-	-	-	-	-	-
LR 6 (7)	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
LR 6 (8)	-	+	+	+	-	+	-	+	-	+	-	-	-	-	-
LR 6 (9)	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-
PH 1 (10)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
PH 1 (11)	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-
PH 1 (12)	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-
PH 1 (6)	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-
PH 1 (7)	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
PH 1 (8)	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-
PH 1 (9)	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
PH 2 (10)	+	+	-	-	-	-	-	-	-	+	-	-	-	-	-
PH 2 (11)	-	-	+	+	-	+	-	+	-	-	-	-	-	-	-
PH 2 (12)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
PH 2 (2)	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-
PH 2 (3)	-	-	+	+	-	+	-	-	+	+	-	-	-	-	-
PH 2 (4)	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
PH 2 (5)	-	+	+	+	-	+	-	+	+	-	-	-	-	-	-
PH 2 (7)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
PH 2 (8)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
PH 2 (9)	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
PH 3	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
PH 3 (10)	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-
PH 3 (11)	-	-	+	-	-	+	-	-	-	+	-	-	-	-	-
PH 3 (12)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
PH 3 (2)	+	+	+	+	-	+	-	+	+	-	-	-	-	-	-
PH 3 (4)	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
PH 3 (7)	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
PH 3 (7)	-	+	+	+	-	-	-	+	-	+	-	-	-	-	-
PH 3 (8)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

Isolates	*fliC*	*stx1*	*stx2*	*eae*	*rfbE*	*hlyA*	*It*	*lal*	*Pap C*	*st*	*bfp*	*Agg*	*cdtB*	*IpaH*	*EagR*
PH 3 (9)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-
PH 4 (10)	-	+	+	+	-	-	-	+	-	+	-	-	-	-	-
PH 4 (11)	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-
PH 4 (12)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
PH 4 (5)	-	+	+	-	-	+	-	-	+	+	-	-	-	-	-
PH 4 (6)	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-
PH 4 (7)	-	+	-	+	-	-	-	+	-	+	-	-	-	-	-
PH 4 (8)	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
PH 4 (9)	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-
PH 5 (10)	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-
PH 5 (11)	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-
PH 5 (2)	-	+	+	+	-	-	-	+	+	-	-	-	-	-	-
PH 5 (3)	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-
PH 5 (4)	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-
PH 5 (5)	-	-	+	-	-	+	-	-	+	+	-	-	-	-	-
PH 5 (6)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
PH 5 (7)	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-
PH 5 (8)	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PH 5 (9)	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-
PH 6 (10)	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-
PH 6 (11)	+	-	+	+	-	-	-	+	-	-	-	-	-	-	-
PH 6 (12)	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-
PH 6 (2)	+	-	+	+	-	-	-	+	-	+	-	-	-	-	-
PH 6 (3)	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-
PH 6 (4)	-	-	+	+	-	+	-	+	-	-	-	-	-	-	-
PH 6 (5)	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-
PH 6 (6)	+	+	+	-	-	+	-	-	-	+	-	-	-	-	-
PH 6 (7)	-	-	+	+	-	+	-	+	-	-	-	-	-	-	-
PH 6 (8)	-	+	+	-	-	+	-	+	+	-	-	-	-	-	-
PH 6 (8)	-	-	-	+	-	+	-	-	-	+	-	-	-	-	-
PH 6 (9)	+	+	+	-	-	+	-	-	+	+	-	-	-	-	-
PH 7 (7)	+	-	+	+	-	+	-	+	-	+	-	-	-	-	-

Figure 4.11 presents a proportional breakdown of virulence genes including *flic*, *stx1*, *stx2*, *eae*, *rfbE*, *hlyA*, *It, lal*, *Pap C*, *st*, *bfp* and *Agg* identified in waste dump site soil samples extracted from the six informal settlements.

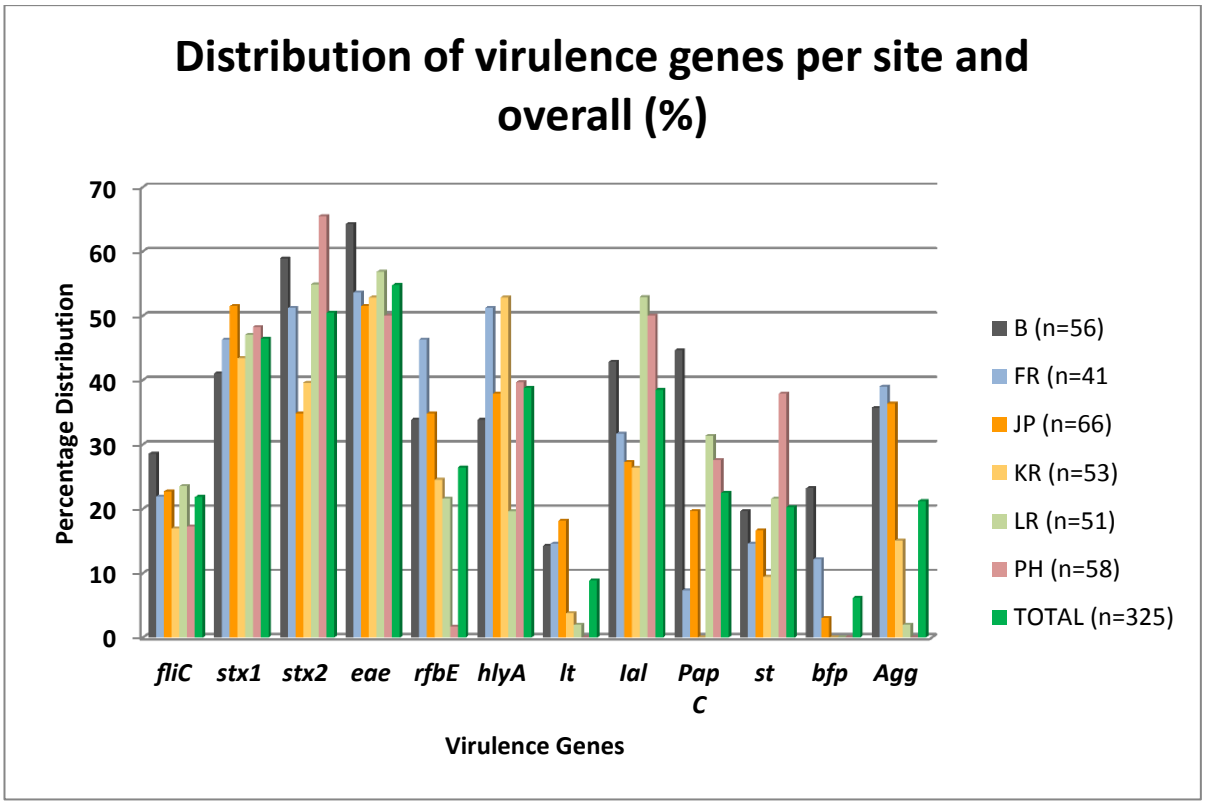

Figure 4.11: Distribution of virulence genes per waste dump site and overall (%).

For the n = 325 *E.coli* samples extracted from waste dumps across all six chosen settlements, the following virulence genes were detected: *fliC* (21.85%); *stx1* (46.46%); *stx2* (50.46%); *eae* (54.77%); *rfbE (*26.46%); *hlyA* (38.77%); *It* (8.92%); *Ial* (38.46%); *PapC* (22.46%); *st* (20.31%); *bfp* (6.15%) and *Agg* (21.3%). The *eae* (54.77%) and the *bfp* (6.15%) genes were the highest and lowest prevalence detected across all six waste dump sites.

The distribution of the virulence genes for the 325 *E.coli* isolates is shown in Table 4.14. Three of the fifteen virulence genes, viz *cdtB*, *IpaH*, and *EagR* were not detected in any of the isolates.

The isolates were grouped into various pathotypes based on the virulence genes they harboured (Table 4.15).

Table 4.15: Associations between virulence genes identified and *E.coli* pathotypes

PATHOTYPE		ASSOCIATED VIRULENCE GENE (S)		
EHEC	Enterohaemorrhagic *E.coli*	*stx1*	*stx2*	*eae*
EPEC	Enteropathogenic *E.coli*	*eae*	*bfp*	
ETEC	Enterotoxigenic *E.coli*	*st*	*lt*	
UPEC	Uropathogenic *E.coli*	*papC*	*hlyA*	
EAEC	Enteroaggregative *E.coli*	*agg*		

The results from the cluster analysis based on the distribution and combination of virulence genes in the *E.coli* isolates as detailed in Table 4.15 are presented as corresponding *E.coli* pathotypes in Table 4.16. The overall distribution comprised 15.08% EHEC strains, 1.54% EPEC strains, 1.85% ETEC strains, 21.23% EAEC strains and 7.38% UPEC strains in waste dumps across all six study locations.

Table 4.16: Prevalence of DEC-associated virulence genes identified in 6 waste dumps

	SAMPLE GROUP						
PATHOTYPE	B	FR	JP	KR	LR	PH	TOTAL
	n= 56	n=41	n=66	n=53	n=51	n=58	n = 325
EHEC	8 (14.28%)	5 (12.19%)	7 (10.60%)	4 (7.54%)	12 (23.52%)	13 (22.41%)	49 (15.08%)
EPEC	2 (3.57%)	1 (2.43%)	2 (3.03%)	0	0	0	5 (1.54%)
ETEC	0	1 (2.43%)	4 (6.06%)	0	1 (1.96%)	0	6 (1.85%)
EAEC	20 (35.71%)	16 (39.02%)	24 (36.36%)	8 (15.09%)	1 (1.96%)	0	69 (21.23%)
UPEC	7 (12.5%)	2 (4.87%)	4 (6.06%)	0	4 (7.84%)	7 (12.06%)	24 (7.38%)

4.4 RELATIONSHIP BETWEEN DEC PATHOTYPES IDENTIFIED IN WASTE DUMPS AND ITS SIGNIFICANCE AS ETIOLOGICAL AGENTS OF CHILDHOOD DIARRHOEA

A chi-square statistical test was performed to assess the relationship between the four DEC pathotypes (EHEC, EPEC, ETEC, EAEC) identified in waste dumps samples and its distribution among the six study areas as potential exposure sources of childhood diarrhoea as shown in Table 4.17.

Table 4.17: Relationship between EHEC, EPEC, ETEC and EAEC pathotypes identified in waste dumps and its exposure distribution across the six chosen informal settlements

Relationship between identified pathotype-exposure and location of dumps in the Burnwood, Foreman Rd, Jadhu Pl, Kennedy Rd, Lacey Rd and Puntans Hill informal settlements	**P-value 0.0011***

A significant *P* = 0.0011 was calculated overall, across the six informal settlements and these locations overall propensity to harbour the four pathotypes identified within waste dumps in this study.

This chapter presented the results of a two-phased study strategy. First, the questionnaire-based survey in relation to mothers' and/or primary caregivers' educational status and their KABP towards domestic waste management and household and community risks relating to childhood diarrhoea and secondly, the presence of environmental *E.coli* isolates and specifically DEC recovered in waste dumps was presented. Chapter 5 discusses the implications of both sets of data obtained.

CHAPTER 5

DISCUSSION

5.1 OVERVIEW

This chapter discusses the results and is guided by the overall aim and objectives of the study. The first objective included the results of respondents' characteristic traits and their perceptions of social and environmental determinants that may have contributed to diarrhoeal prevalence in children under-five.

Significant associations between mothers and/or primary caregivers KABP towards domestic waste and greywater disposal, method of sanitation, personal and domestic hygiene and zoonotic agents found in waste dumps were identified as contributory household and environmental risk factors of childhood diarrhoea in the under-five age group. Note must be taken that risk factors were previously unclear, unspecified or misunderstood and its individual and combined significance towards this disease prevalence had not been causally investigated or evaluated in the eThekwini Municipality.

For objective 2, soil samples were collected from each of the largest waste dump sites located within the six selected informal settlements. The subsequent laboratory analyses of these samples sought to first determine the presence of *E.coli* as an indicator of faecal contamination and more specifically, to identify DEC pathotypes via phenotypic and molecular methods, thereby implicating waste-dumps as secondary reservoirs of childhood diarrhoea.

For objective 3, the recovery of four DEC subgroups or pathotypes from waste dumps is then further discussed. A search of the literature has revealed information that critically implicates and links these four etiological

agents in various ecological reservoirs including dumps and soil, thereby highlighting its significance as secondary sources of infection including contracting of diarrhoea, particularly among children that played in and near these waste sites.

It is hoped that these results guide local stakeholders in implementing necessary measures and promoting behavioural change amongst its numerous informal settlements. Additionally, these results may aid in addressing the urgency, evaluating the adequacy and assessing the sustainability of current community educational and clean-up campaigns periodically undertaken by the eThekwini Municipality. It is envisaged that the information provided here will offer further insight in designing future multi-faceted interventions. This includes targeting mothers' health education and literacy in terms of their knowledge, attitudes and practices which could reduce DEC exposure and transmission, thereby decreasing the prevalence of childhood diarrhoea.

5.2 SOCIO-DEMOGRAPHICS AND ITS ASSOCIATED IMPACTS ON DIARRHOEAL PREVALENCE

5.2.1 Personal characteristics:

Mothers were the most suitable candidates to be interviewed with almost 92% of the 360 respondents, female. The mean age of the respondents was 30.74 years which supports the 2011 census results i.e. 66% of the population are below the age of 35 years (eThekwini Municipality 2013: 20).

An added issue was that of respondents residing in their respective informal settlements for more than ten years. This highlights the current backlog and difficulty in terms of suitable upgrading or relocation efforts by eThekwini Municipality (eThekwini Municipality 2011: 5). This result suggests that the probability of a short-medium relocation of these residents is unlikely.

Therefore, these six informal settlements will continue to be subjected to existing unhealthy environments and challenges which are known to affect and influence childhood diarrhoea prevalence (Unger and Riley 2007: 1562; Unger 2013: 801).

5.2.2 Household occupancy:

The average number of persons occupying each dwelling was nearly 4 which is considerably higher than the national South African mean for informal settlements of 3.2 per household (HDA 2012: 35). Although the actual size and number of rooms versus number of occupants per dwelling were not recorded, the high concentration and density of shacks and walk-through observations suggested inadequate internal living areas that had poor infrastructural services. Lukeman *et al*. (2014: 81) quoted that the household is a better indicator of individual health status, noting “adequate living space, privacy, ventilation, lighting and structural integrity with basic infrastructural services” as essential elements in reducing diseases including childhood diarrhoea. The six study areas, therefore, may constitute typical unhealthy living conditions and environments that may influence childhood diarrhoea incidence and prevalence.

5.2.3 Socio-economic status:

Poverty and low socio-economic levels are two inter-related and key characteristics of informal settlements and are often shown, amongst other factors, in the high unemployment rates (Unger 2013: 799) and this creates a significant relationship between income and health. Saaka (2014: 237) found that mothers of low socio-economic status were unable to apply and afford appropriate childcare practices and treatment among children that experienced diarrhoea and malnutrition. Duncan, Ziol-Guest and Kalil (2010: 307) noted that household income amongst impoverished communities considerably influenced early childhood development, abilities and

achievements and can significantly affect the child's post-five age growth and development.

It is, therefore, concerning that 84% of respondents were unemployed leading to a high dependency on monthly government grants. This is however, consistent with most people living under impoverished conditions in informal settlements across South Africa (Marx and Charlton 2003: 15; Moiloa 2007: 45; Phetha 2010: 70; HDA 2013: 36). Household income received averaged to approximately R590.20 per month. This monthly income equated to R19.60 per day which support the findings of Phetha (2010: 70) whose study showed that the Lacey Road informal settlement, one of the areas included in this study, are low income earners who are mainly domestic workers and street vendors. Respondents are therefore subjected to financial hardships with most surviving below the poverty threshold.

5.2.4 Educational status:

Nearly 94% of respondents had either a primary or secondary level of education with 1.7% having no schooling, embracing the reported 7% illiteracy among South African adults (HDA 2012: 51). A UN-HABITAT report (2009: 22) indicated that as a guideline, individuals with no schooling may be considered illiterate and those who have attended grade five of primary school may be classified as literate. Therefore, 37.9% and 57.9% of respondents who had a primary and secondary level of education respectively may be considered as literate individuals.

However, the lack of further training and education may impact on their knowledge, attitude and belief systems with respect to environmental and bacteriological risks of childhood diarrhoea and the way in which they perceive and manage this childhood illness. Choube *et al*. (2014: 285) assessed various aspects of maternal knowledge in relation to childhood

diarrhoea in a study in India and found that basic levels of caregiver educational status significantly increased the risk of contracting the illness ($P < 0.001$). However, in a similar Nigerian study by Yilgwan and Okolo (2012: 221), 54% of mothers who attained a primary school education showed a lower prevalence of diarrhoea among their children as they had better knowledge and understood the consequence of implementing adequate hygiene measures, the importance of suitable childcare and healthier feeding practices and were more conscious and aware of risk factors related to this disease.

In view of the profound effect of maternal education towards childhood diarrhoea prevalence, the respondents' educational status will be further assessed below in relation to waste management practices and methods of sanitation.

5.3 PREVALENCE OF UNDER-FIVE DIARRHOEA

The prevalence of diarrhoea was based on a child experiencing diarrhoea at least 1 month prior to the interview with 97% and 3% of households, respectively having either 1 child or 2-3 children under-five meeting this criteria. Although the prevalence rate of childhood diarrhoea in this study was approximately 2-3 times greater than similar community studies among children under-five, it was consistent with most KABP studies (Oketcho *et al.* 2012: 83; Mihrete, Alemie and Teferra, 2014: 102; Gupta *et al*. 2015: 25).

The extremely high burden of childhood diarrhoea in this study is indicative of its endemic nature and persistence in the African continent, including a leading cause of death in the under-five age category in South Africa (Boschi-Pinto, Lanata and Mendoza 2006: 232; Chola *et al*. 2015: 394). Okethcho *et al*. (2012: 83) and Unger (2013: 801) noted that high diarrhoeal prevalence was a likely result of young children, particularly those living in informal settlements, having weak immune systems and frequent exposure to

infectious enteric pathogens. Therefore the children living in the study areas may be at an increased risk of recurrently contracting diarrhoea as was also evidenced by Avachat *et al*. (2011: 72) whose study showed that almost 10% of under-five children in India experienced recurrent diarrhoea, usually greater than 4-6 episodes per annum.

Mengistie, Berhane and Worku (2013: 447) explained that the occurrence of diarrhoea in children are complex and the interaction between demographic and socio-economic determinants including environmental and behavioural factors influence the prevalence rates of this illness. Although the present study did not consider gender distribution of children, a number of studies have shown that the male gender in the under-5 year age group was a significant determinant for contracting diarrhoea (Al Saady, Al-Alwany and Nasheit 2006: 57; Yongsi *et al*. 2008: 213; George *et al*. 2014: 1192).

5.4 KNOWLEDGE, ATTITUDES AND PRACTICES RELATING TO HOUSEHOLD WASTE MANAGEMENT AND SANITATION

The present KABP results related to mothers' and caregivers' domestic waste management practices at household and community level provided invaluable information that may assist key stakeholders in addressing community needs, problems and concerns in terms of improving their quality of life and overall health status.

5.4.1 Relationship between mothers' and/or primary caregivers' educational status and knowledge of waste management

The majority of respondents had a fair level of knowledge relating to waste management thereby indicating that there is a formal waste collection service within all six study areas. This was also confirmed in an email communication on 3 September 2015, in which N. Khuzwayo of the eThekwini DSW Unit, indicated that private contractors engaged by his department collected refuse

at identified pick-up points from all six informal settlements on a weekly basis. Refuse bags are also supplied by these contractors and a person nominated in each locality is responsible for its distribution.

Table 4.4 shows that there was a strong relationship overall between respondents' educational status and their knowledge of waste management within their respective communities. The overall pattern indicates that education does play a significant role in terms of who collects their domestic waste, the frequency of waste collection and the number of refuse bags they receive on a weekly basis. Thus, there is a vertical progression in terms of education levels, i.e. the better educated the respondent, the more likely they would understand the schedule and dynamics of waste management services available in their areas.

However, in spite of respondents' knowledge regarding their awareness of current waste management and collection services, they persisted with indiscriminate dumping suggesting a lack of understanding in the complexities of these dumps as potential reservoirs of diarrhoeal-causing pathogens.

5.4.2 Relationship between mothers' and/or primary caregivers' educational status and their attitudes towards discarding of domestic waste and greywater disposal

Respondents' education levels and their attitudes and reasons for disposing waste in their settlements showed no significance as shown in Table 4.5. This clearly indicates that irrespective of their level of education, some respondents persisted with indiscriminate dumping due to the following reasons:

- Designated waste area was situated far away from household;
- Designated waste area was too dirty;

- Convenient and easy to throw waste into nearby waste dump; and
- They believed everybody else in settlement discarded their waste into dumps, so they were entitled to do the same.

These findings were similar to a study performed in Tanzania, which showed that irrespective of level of education attained, mothers persisted with indiscriminate dumping of household waste within their respective communities (Chengula, Lucas and Mzula 2015: 61). Almost 58% of respondents in this study had access to a waste collection point < 50 m away, yet they continued with indiscriminate dumping practices thereby contributing to the ubiquitous formation and spread of open waste dump sites. In a study in Swaziland, Abul (2010: 64) found that residents living within 200 m of waste dumps succumbed to a number of illnesses including diarrhoea. Therefore children that frequented waste dumps in the present study may be at elevated risk of contracting diarrhoea due to waste-dump exposure and contact as was evidenced in a study in Pakistan in which 10% of children experienced diarrhoea through similar open environmental reservoirs (Bashir, Anwar and Qasim 2014: 836).

Respondents' incorrect and unconcerned attitudes towards waste management is indeed a major cause of careless disposal of household waste which may also reflect their general apathy and lack of civil pride even though they are subjected to impoverished and low socio-economic status. However, George (2004: 1) indicated that peoples' attitudes and perceptions are 'learned response sets and thus can be modified through health education'. This aspect of behaviour change is further discussed in the following chapter.

5.4.3 Relationship between mothers' and/or primary caregivers' educational status and their behaviour related to household waste management practices and methods of sanitation

This study showed a positive correlation or pattern (P = 0.002) between respondents' educational level and those that discarded their waste into dumps when calculated collectively across all six study areas. Education appears to be a vital element in terms of whether mothers and/or primary caregivers practiced indiscriminate dumping, that is, the less educated the respondent, the higher the probability and frequency of practicing indiscriminate dumping, which over a period time accumulates into voluminous waste dumps.

Studies have shown that indiscriminate waste dumping is a phenomenon experienced in informal settlements across South Africa and evidently Durban is no exception (Moiloa 2007: 51; Richards, O'Leary and Mutsonziwa 2007: 379). Phetha (2010: 75) revealed that in 2009, residents of the Lacey Road informal settlement, one of the six subgroups interviewed in this study, discarded waste in major proportions throughout the locality. Six years later, indiscriminate dumping continues to pose an environmental risk to these residents and indeed those living in the other five selected settlements. Given the apparent 'permanence' of waste dumps caused by habitual, indiscriminate dumping and the previously mentioned backlog with relocation of settlements in the EMA, it stands to reason that the threats and exposure to pathogenic agents from these environmental reservoirs may exacerbate childhood diarrhoea incidence and prevalence within these communities.

In a KAPB study undertaken by Banjo, Adebambo and Dairo (2009: 64), the authors concluded that mothers with a tertiary education understood and recognized the need for scientific and proper disposal of domestic waste. This is very pertinent among the six chosen informal settlements as only 2.5% of respondents attained a tertiary level of education which could

possibly explain the high turnover of indiscriminate domestic and greywater disposal. Evidently, mothers and caregivers that had a basic primary school or at least a single level of secondary education did not comprehend the magnitude related to faecal pathogens that may be transmitted via waste-dump exposure, thereby intensifying environmental risks towards childhood diarrhoea prevalence.

The majority of respondents did not have individual toilet facilities within their households, with most using communal flush and pit latrines. Table 4.6 also showed a significant positive association overall between mothers' and/or caregivers' educational status and their method of sanitation (P = 0.000) which again clearly demonstrated the importance of education in choosing an acceptable method for their sanitation needs.

Notwithstanding the above finding, 77% of mothers and/or primary caregivers also believed that the ablution facilities supplied and maintained by the eThekwini Municipality were dysfunctional, unhygienic and often blocked or non-operational and this finding together with educational status may be the contributory factors for some respondents and their under-five children opting for 'plastic toilets' or openly defecating near waste dumps.

According to UN-HABITAT (2009: 19), nearly 1 in 4 people in developing countries practiced indiscriminate defecation and together with unsafe disposal of children's excreta caused faecally-contaminated external environments, primarily resulting from inadequate and unsuitable sanitation. This is very pertinent to the current study because inadequate ablution infrastructural services often plagued with unhygienic and accessibility constraints continue to intensify the growing body of literature with regard to poor usage and optimization of these facilities (Kulabako *et al*. 2010: 238) particularly among children living in urban informal human settlements.

It is noted that although only 3.1% and 13.7% of respondents and children under-five respectively, openly defecated in open spaces near waste dumps, 66.9% of mothers also confirmed that their children did frequent these faecally-contaminated sites, thereby increasing exposure risk to ambient pathogenic bacterial agents.

5.4.4 Risks posed to children (< 5 years) as a result of open waste dumps

Figure 4.7 show that children from the majority of households (80.8%) played in or near waste dumps which appeared to be a common practice across all six settlements. This may be attributed to the lack of playgrounds, recreational areas or well-maintained open spaces within these informal localities. Although 54% of mothers and/or primary caregivers agreed that children may be exposed to health and safety risks whilst playing in or near waste dumps, an alarming 22% of the respondents believed that this childhood practice is acceptable and safe and therefore did not pose a health hazard.

Table 4.8 illustrates a positive correlation between the risks associated with children playing in or near waste dumps and three household practices including mothers and/or primary caregivers disposal of greywater (P = 0.008), discarding domestic waste into dumps (P = 0.000) and their type of sanitation utilized (P = 0.014). These associations demonstrated that a higher frequency of domestic solid waste and greywater disposal including the usage of plastic toilets and open defecation increased childrens' waste-dump exposure levels to pathogens, thereby showcasing diarrhoea as a serious health risk among a highly sensitive and vulnerable under-five subpopulation.

5.5 KNOWLEDGE, ATTITUDES AND PRACTICES RELATING TO CHILDHOOD DIARRHOEAL MANAGEMENT

5.5.1 Relationship between respondents' educational status and knowledge of childhood diarrhoea

In this study, significant associations were recorded between mothers' educational status and symptoms of childhood diarrhoea including the passage of three or more stools (P = 0.012), abdominal pain (P = 0.040), nausea (P = 0.010), blood in stool (P = 0.000) and sunken eyes (P = 0.000). The 8.3% of respondents that recognized blood in stools may indicate that these children may have suffered with a more severe form, i.e. bloody diarrhoea which is often associated with fever, headache, anorexia, moderate-severe cramping and lower abdominal pain (Kelly 2015: 255). The above findings are extremely pertinent as Merga and Alemayehu (2015: 28) have noted that mothers with substantial knowledge of symptoms related to childhood diarrhoea are capable of early referral and appropriate treatment whilst their inability or failure to recognize these danger signs could progress to major complications or even death.

There was no significant correlation between mothers and/or primary caregivers level of education and 'germs' or bacterial infections as a causative agent of childhood diarrhoea. However, the 88.6% frequency reported across all six study areas demonstrated that repondents did have a a basic understanding that 'germs' or bacteria may actually be responsible for the disease.

However, the earlier results illustrating high frequency of children that played amongst faecally-contaminated waste dump sites and a 22% confirmation by by respondents that such childhood behaviour did not warrant or constitute health risks suggests a poor understanding and comprehension of bacterial pathogens found in waste dumps, its associated transmission pathways and

its ability to cause diarrhoea. In spite of a significant association between mothers' educational status and dirty hands (P = 0.001) recorded as a risk factor of diarrhoea, seemingly there is a lack of understanding that childrens' post waste-dump exposure may contaminate hands, thereby increasing probability of contracting this illness, yet again emphasizing a crucial need to educate these guardians in identifying and combatting viable reservoirs and potential transmission pathways.

Awisan *et al*. (2011: 30), Osunwoke and Kuforiji (2012: 62) and Ali *et al*. (2014: 590) found a number of bacterial pathogens in waste-dump soil including *E.coli* which are known etiological agents of diarrhoea, hence the common practice of children playing in sites that have been polluted and contaminated by anthropogenic activities as in the case among the six study areas inevitably increase their hand-to-mouth and object-to-mouth exposure of bacterial agents and infections, thereby increasing their susceptibility to this ilness.

5.5.2 Relationship between respondents' educational status and attitudes towards personal hygiene practices and risks associated with childhood diarrhoea

This study also showed that mothers' and primary caregivers' attitudes and behaviour towards personal hygiene practices may influence the severity of risks involved with children contracting the illness. Table 4.10 showed that there is a significant positive association among respondents' educational status across all six study areas and their attitudes and behaviour in possibly reducing prevalence of childhood diarrhoea. This is evidenced by 93.6% of respondents' attitudes or viewpoints showing that childhood diarrhoea is in fact preventable and that safe and hygienic disposal of faecal and domestic waste (P = 0.000) and safe and hygienic food preparation (P = 0.000) are important determinants or household practices that could reduce the transmission and spread of the illness.

These two findings were similar to a study in Nigeria which showed that the risk of diarrhoea among children under-five was significantly higher among those whose mothers did not wash hands before food preparation ($P < 0.05$) and those that practiced unsafe waste disposal ($P = 0.011$) (Oloruntoba, Folarin and Ayede 2014: 1001). In a study by Augustina *et al*. (2013: 989) poor food hygiene practices was also significantly associated with a high incidence of diarrhoea in the under-five age group. Hence this study identified two important perceived risk factors including mothers and caregivers safe and hygienic disposal of waste and excreta and hygienic food preparation that could predispose under-five children to diarrhoea. However, the overall high prevalence rate of childhood diarrhoea within these communities suggests that in reality, these two practices were non-habitual, inconsistent or rarely practiced.

Notwithstanding a significant value ($P = 0.001$) calculated for mothers washing their children's hands prior to consuming their meals across all six study areas, only 81 (56.3%) and 63 (43.8%) washed with water only and water and soap, respectively, among all n = 360 households in the present study. This means that 60% or 216 households did not practice washing of hands before children ate their food. In a study amongst primary school children in Malawi, Grimason *et al*. (2014: 35) revealed a high presence of *E.coli* on the hands of most children (75%; 95% CI 96-86%) and the consumption of food without handwashing was implicated in a number of diarrhoeal cases in children <5 years (Luby *et al*. 2011: 5; Nizame *et al*. 2013: 1179). Therefore irregular or no handwashing among children under-five may also contribute to hand-to-mouth transfer of pathogens causing diarrhoea.

The earlier finding that 98.3% of mothers and/or primary caregivers had some level of education illustrates that education does in fact play a critical role in influencing the way they act or behave in terms of personal hygiene

practices as positive correlations were recorded between educational status and the frequency of washing their hands after toilet usage, assisting child in toilet, before feeding child and food preparation as shown in Table 4.10. Therefore the higher the level of education attained, the higher the probability of mothers consistently engaging in hygienic personal and household practices. This may also indicate that a basic primary school education was not sufficient to provide mothers with the necessary knowledge to understand the critical need for these hygiene practices which may also explain the elevated, even endemic-like prevalence of childhood diarrhoea across the study settlements.

A study in Bangladesh by Luby *et al*. (2011: 1) showed that households in which mothers and caregivers practiced washing of one hand with water only (OR = 0.78; 95% CI = 0.57 – 1.05), both hands with water only (OR = 0.67; 95% CI =0.51 – 0.89) or washed at least one hand with soap and water (OR = 0.30; 95% CI = 0.19 – 0.47) experienced less diarrhoeal cases amongst their children compared with households that did not practice handwashing. Another finding of the same study showed that in households where mothers and caregivers washed their hands with soap and water after toilet usage, children had experienced less diarrhoea compared to households that did not practice this habit.

As noted in Table 4.11, a large proportion of respondents also indicated that the harbourage of pests including pets and animals foraging waste dumps within their respective settlements could also transmit pathogens into their households. A number of studies have also shown that the presence of flies, rodents, cockroaches in bacteria-rich environments such as waste dumps have led to the transmission of childhood diarrhoea, particularly among children living in informal, impoverished settlements characterized by inadequate waste management and sanitation, overcrowding and squalid living conditions (Nazni *et al.* 2005: 225; Osumanu 2007: 59; Ambu 2014: 02; Gebru, Taha and Kassahun 2014: 10). Hence, the evident risks of these

pests as vectors of childhood diarrhoea is undoubtedly a serious concern across all six selected settlements which is plagued with indiscriminate dumping and environmental contamination with human and animal faecal matter in close proximity to households.

In addition, Figure 4.9 shows that 43% of respondents agreed that pets could be a source of disease transmission with 27.3% disagreeing. This difference in opinion is significant (P = 0.004). With the exception of Dyjack (2013: 25), other studies have concluded *E.coli* transmission from the faeces of dogs, cats, poultry to humans including cattle, pigs, goats as reservoirs of zoonotic diarrhoeal diseases (Caprioli *et al*. 2005: 295; Shrivastava, Joseph and Singh 2011: 3736; Chen *et al*. 2012: 152).

In view of dogs, cats and poultry that foraged waste dumps and subsequently frequenting areas near and within households in this study, the potential for transmitting bacterial pathogens amongst children through these domestic and stray animals is logically and reasonably concerning. Thus, pets and stray animals may be considered as potential mechanical vectors of diarrhoeal pathogens, particularly within informal settlements plagued with extensive indiscriminate waste dumps, a gap identified for further investigation.

5.5.3 Relationship between respondents' educational status and practices towards treatment of children with diarrhoea

The high percentage (85.3%) of mothers that took their children to local PHC clinics indicated that they do have access to health care and the three clinics that service the six study areas are either within walking distance or on a bus and/or taxi route, thereby making these facilities easily accessible.

The use of oral rehydration solutions (ORS) has been observed as a common treatment option amongst the majority of caregivers in all six study

areas as shown in Table 4.12. This study demonstrated a high usage of ORS and the majority of mothers and/or primary caregivers also correctly prepared ORS before administering to children with diarrhoea. Mothers and/or primary caregivers have a satisfactory knowledge of treating children with acute diarrhoea as they also realized the significance of giving children more fluids whilst experiencing this illness.

This finding was consistent with a study by Choube *et al*. (2014: 286) that noted mothers and caregivers in India had a high knowledge of salt-sugar solution (53.2%) followed by commercially available ORS (40.7%) as rehydration treatment for children under-five. Sillah (2012: 43) showed a significant relationship between maternal education status and adminstration of readymade ORS ($P < 0.05$), that is, the higher the level of education attained by mothers, the better their knowledge and use of ORS in the treatment of childhood diarrhoea. The easy accessibilty and treatment at PHC clinics including an adequate level of knowledge in ORS usage during mothers' management of childhood diarrhoea understandably did not affect childhood disease prevalence, indicative of critical inherent risks within these communities, thereby contributing to new and/or recurrent cases which remains a major community challenge.

The KABP study had identified a number of important household risk factors that could predispose children under-five to diarrhoea, however Dasgupta (2008: 298) has cautioned that these behavioural factors should and must not be analyzed in isolation as determinants of this illness, as a number of external and community determinants which are sometimes beyond the control of the individual household may be implicated. One of these external determinants may include DEC pathogens found in waste dumps located within informal settlement communities.

5.6 SOIL SAMPLING FROM WASTE DUMPS

Pathogenic *E.coli* strains pose a serious and highly probable risk to children living in informal settlements and who are exposed to indiscriminate waste dumps contaminated with human and animal excreta. The following sections will therefore highlight its persistence and survival in waste-dump soil and other media which further supports the role of these ecological reservoirs in childhood diarrhoea transmission.

5.6.1 The presence of pathogenic *E.coli* in waste dump soil

Numerous studies have identified and enumerated *E.coli* and pathogenic *E.coli* in water bodies across South Africa, however no known studies to date have comprehensively determined the virulence gene signatures of these environmental isolates in waste dumps to illustrate potential risks to children residing in informal settlements (Grabow *et al*. 2003: 41; Lamprecht *et al*. 2014: 4; Ndlovu *et al*. 2015: 8). Thus, objective 2 was geared toward a characterization of *E.coli* strains collected and enumerated from waste dumps across the six study settlements in an effort to demonstrate and establish individual pathotypes among the *E.coli* isolates after detection of specific virulence genes harboured by the isolates via PCR.

The faecal coliform levels in the waste-dump soil samples as presented in Table 4.13 were found to vary, and ranged from 4000 to as high as 2100000 CFU/ml. The average *E.coli* population at each dump site comprised of 64666 CFU/ml (Burnwood), 66166 CFU/ml (Foreman Road), 932666 CFU/ml (Jadhu Place), 26791 CFU/ml (Kennedy Road), 28333 CFU/ml (Lacey Road) and 232166 CFU/ml (Puntans Hill) indicating that Jadhu Place and Lacey Road dump sites contained the highest and lowest faecal contaminant loads, respectively.

Whilst there are no guidelines in terms of evaluating faecal coliforms as an indicator of microbiological pollution in waste dumps or soil, the Department of Water Affairs and Forestry (DWAF) (1996: 41) have listed this group of organisms as an indicator of faecal pollution and its ability to transmit infectious disease including diarrhoea through various potable, recreational and agricultural water bodies. Therefore, the high level of *E.coli* across all waste dump sites reported may be used as a practical indicator of faecal pollution. The DWAF (1996: 42) report also indicated that human intermediate contact of > 4000 CFU/ml faecal coliforms carried a highly probable risk of contracting diarrhoea, thus the mean of 255326 CFU/ml in waste dumps across all six settlements, is suggestive of higher risk-exposure to bacterial pathogens, thereby escalating probability of acquiring diarrhoea particularly among children that were reported to frequent these sites in the first-phase of this study.

Three hundred and twenty five of the 400 faecal coliform isolates tested positive for *E.coli* based on the PCR detection of the conserved *mdh* gene in *E.coli.* The DWAF (1996:42) report noted that these bacterial species may constitute up to 97% of coliform bacteria in human faeces, thereby indicating high levels of faecal contamination across all waste dumps. The use of plastic toilets and open defecation including domestic and wild animals observed in or near waste dumps as depicted in Figures 4.2 and 4.3 and Table 4.11 respectively, could also represent a logical elucidation of the high *E.coli* levels reported. As previously mentioned, the lack of guidelines for *E.coli* levels in waste dumps or soils creates a huge challenge in truly quantifying risks of acquiring infectious diseases, however, the reported under-five children's waste dump exposure and contact arguably predisposes this vulnerable subpopulation towards community-acquired diarrhoea.

A number of previous studies have isolated *E.coli* isolates from waste dump soil as an indicator of faecal contamination (Avery *et al*. 2005: 818; Brennan *et al*. 2010: 2178; Awisan *et al*. 2011: 32), but their virulence properties are

not routinely determined and evaluated to reveal serious disease-causing risk to susceptible populations. Hence, the 325 *E.coli* isolates were subjected to mono- and multiplex PCR with gene-specific primers (Table 3.2) to screen for virulence genes. The primer sets used in the present study were selected and applied for detection of DEC strains based on their sensitivity and specificity in PCR assays utilized in similar studies (Bai, Shi and Nagaraja 2010: 86; Kim *et al*. 2010: 1206; Bugarel *et al*. 2011: 144; Jeshveen *et al*. 2012: 462).

Figure 4.11 shows the distribution of virulence genes from the 325 *E.coli* isolates extracted from waste dumps. The *eae* (54.77%) and the *bfp* (6.15%) genes were the highest and lowest recovered genes extracted in waste dump soil.

The genotypic classification of the identified virulence genes included its subsequent grouping to illustrate DEC pathotypes found in the waste dumps. These included the detection of the enterohaemorrhagic *E.coli* (EHEC; *stx1*; *stx2*; *eae*), enteropathogenic *E.coli* (EPEC; *eae*; *bfp*), enterotoxigenic *E.coli* (ETEC; *st*; *It*), enteroaggregative *E.coli* (EAEC; *agg*) and UPEC (*papC*; *hlyA*). Two of the six known *E. coli* pathotypes, namely enteroinvasive *E.coli* (EIEC) and diffusely adherent *E.coli* (DAEC) pathotypes were not detected. The *agg* gene carried by the EAEC pathotype and the *eae* and *bfp* genes carried by the EPEC pathotype were the most (21.23%) and least (1.54%) prevalent genes detected, respectively, in waste dump soil samples. In addition to the four DEC pathotypes identified, an extra-intestinal pathotype, namely uropathogenic *E.coli* (UPEC) which carried the *papC* and *hlyA* genes were detected in 7.38% of the *E.coli* isolates.

UPEC is responsible for more than 80% of urinary tract infections (UTI) which is currently ranked as one of the most prevalent infectious diseases amongst all age groups and can progress to renal failure if left untreated (Neamati *et al*. 2015: 6). A number of studies have isolated UPEC strains in urine

samples of children with UTI (Ramos *et al*. 2011: 1588; Navidinia *et al*. 2013: 76; Tarchouna *et al*. 2013: 450; Yun *et al*. 2014: 455) and its multi-drug resistance against antibiotics reduces treatment options, thereby increasing medical costs and mortality (Navidinia 2014: 513; Neamati *et al*. 2015: 1). Thus, children frequenting waste dumps within informal settlements are also potentially at risk of UTI infection. However, to proceed and conclude the discussion for purposes of the study's overall aim and objectives, only DEC pathotypes identified in waste dumps which now constitute secondary reservoirs for acute childhood diarrhoea were considered.

Even though not detailed in the results chapter, it is worth noting that the temperature of the soil samples from the four waste dump sampling sites ranged between 25^{o}C and 36^{o}C (Annexure I), which supports van Eslas' *et al*. (2011: 178) finding that optimal temperature of *E.coli* populations is greater than 30^{o}C which is necessary for its growth and survival in soil-related habitats.

As expected, high levels of *E.coli* were present in waste dumps which were ubiquitously strewn and accumulated across all six study settlements. However, the subsequent detection of DEC strains imply that beyond the indication of faecal-contamination, waste dumps clearly represented secondary environmental reservoirs of diarrhoea particularly among young, immunocompromised and undernourished children that frequented these sites.

This study identified four DEC pathotypes in waste-dump soil across all six informal settlements based on their respective virulence genes that are encoded with specific factors (Kaper, Nataro and Mobley 2004: 126). These pathotypes are known to induce acute diarrhoea, among other types, in the under-5 age category. To the best of knowledge, this is possibly the first time that DEC pathotypes have been isolated from open waste dumps due to indiscriminate domestic dumping within informal settlements in Durban.

5.7 ASSOCIATION BETWEEN DIARRHOEAGENIC *E.COLI* PATHOTYPES AND CHILDHOOD DIARRHOEA

The DEC pathotypes recovered in waste-dump soil provided invaluable evidence on the presence of these pathogenic *E.coli* strains across the six chosen informal settlements. This is of paramount importance in our understanding and ability to manage these pathogens from a public health perspective, particularly as it may serve as a secondary reservoir and a real environmental threat towards childhood diarrhoea.

As presented in Table 4.17, there was an overall significant relationship (P = 0.0011) between the pathotypes identified and location of the six settlements, implying that irrespective of where these children were residing, they were all at significant risk of exposure to EHEC, EPEC, ETEC and EAEC when they played or frequented these sites. The mean distribution of all four pathotypes found collectively in each study site comprised 13.39% (Burnwood), 14.01% (Foreman Road), 14.07% (Jadhu Place), 5.65% (Kennedy Road), Lacey Road (6.86%) and Puntans Hill (5.6%) which also shows a higher DEC prevalence in the first 3 study areas compared to the lower levels recorded in the latter three locations.

Furthermore, a number of epidemiological studies (Table 5.1) have associated the four identified pathotypes namely EHEC, EPEC, ETEC and EAEC as the causative etiological agents of under-five childhood diarrhoea. However the presence of more than one DEC strain within each study location could potentially signal elevated and multiple risk and severity of illness among children exposed to waste dumps caused by indiscriminate waste practices. This finding of approximately 40% of positively identified DEC in waste dumps located across all six settlements and its known ability to easily colonize both the small and large bowel mucosa particularly among children under-five (Croxen and Finlay 2010: 26), is cause for serious concern.

Table 5.1: Summary of studies implicating Enterohaemorrhagic *E.coli*, Enteropathogenic *E.coli*, Enterotoxigenic *E.coli* and Enteroaggregative *E.coli*, its associated reservoirs and transmission routes in under-five diarrhoea

***E.coli* pathotype**	**Studies (diarrhoea in <5yr children)**	**Reservoirs**	**Transmission Route**
EHEC (enterohaemorrhagic *E.coli*	Germany & Austria (Verweyen *et al*., 1999) India (Lanjewar and Mathur, 2010) Nigeria (Ifeanyi *et al*., 2015)	Food handlers as asymptomatic carriers; contaminated food, water and milk (Gould, 2011) Cats, dogs, goats chickens, cattle, sheep, (Reilly, 1998; Ramamurthy and Albert 2012)	Person-to-person; ingestion of contaminated food; waterborne transmission and via drinking water contamination (Isaacson *et al*., 1993; Chin 2000)
EPEC (enteropathogenic *E.coli*)	Mexico (Cravioto *et al*., 1988) Brazil (Gomes, Blake and Trabulsi, 1989) Bangladesh (Albert *et al.*, 1995) Several developing countries (Ochoa *et al*. 2008)	Symptomatic or asymptomatic children, asymptomatic adult carriers(Clarke *et al*. 2002) Cattle, sheep, dogs, cats, pigs, chicken and goats (Krause, Zimmerman and Beutin, 2005; Salehi, Badouei and Gohari, 2011)	Predominantly faecal-oral transfer from contaminated hands, weaning foods and fomites (Grabow *et al*., 2003)
ETEC (enterotoxigenic *E.coli*)	India (Chakraborty *et al*., 2001) Bangladesh (Qadri *et al*., 2005) Egypt (Wierzba *et al*., 2006) Tanzania (Moyo *et al*., 2007) Peru (Ochoa *et al*., 2009)	Faecally polluted water bodies (Begum *et al*. 2007) Infected food handlers with poor food handling practices (Jain *et al*. 2008)	Predominantly through the faecal-oral route and exposure and ingestion of contaminated food and drinking water or among children not practicing regular handwashing (Croxen *et al*. 2013)
EAEC (*enteroaggregative E.coli)*	Several developing countries (Huang *et al*., 2006) Tanzania (Moyo *et al*., 2007) India (Rajendran *et al*., 2010) Egypt (Ali *et al*., 2014)	Asymptomatic human carriers (Okeke, 2009) Food handlers (Ounda *et al*., 2008)	Ingestion of contaminated food and water (Pai *et al*., 1997; Scavia *et al.* 2008)

The above review of the four DEC pathogens highlights their individual ability to cause under-five diarrhoea which is exacerbated by human and animal carriers and commonly transmitted by hand-to-mouth transfer which demands highly consistent levels of domestic and personal hygiene especially among children living in informal settlements.

It is evident that the four DEC pathotypes, namely EHEC, EPEC, ETEC and EAEC as presented in Table 5.1 are the responsible etiological agents of under-five diarrhoea worldwide. EAEC was most frequently identified in waste dumps (21.23%) across all six settlements, implying that children that are potentially exposed may be at significant risk of EAEC-associated diarrhoea compared to infection caused by the other identified strains. The recovery of the four pathogenic strains collectively, from waste dumps across all six study settlements highlights a serious and severe risk among children that frequent these sites.

The preceding discussion has revealed that the four pathotypes including EHEC, EPEC, ETEC and EAEC identified among waste dumps, are well known etiological agents of childhood diarrhoea and childrens' frequent exposure in this study highlights and support the well-documented association between DEC and this illness.

5.7.1 Cumulative health risks associated with diarrhoeagenic *E.coli* pathotypes in waste dumps

Due to an alarming paucity of similar studies, i.e. DEC persistence in waste dumps locally or from other parts of the world, these study results could not be assessed or compared to data elsewhere. However, this study confirms the presence of DEC in contaminated domestic waste dumps in Durban's informal settlements, which may have the potential to cause specifically diarrhoea among under-five children. However Achudume and Olawale

(2006: 154) indicated that it is difficult to estimate risk of acquiring a disease through dump-site contact recreation as there is little or no dose-response data. Pathogens responsible for infectious diseases are not routinely measured and reporting is rare unless associated with epidemic outbreaks. Therefore by investigating the presence of DEC within waste dumps and understanding its virulence gene content, this study highlights the dangerous threat of these pathogenic organisms and its potential to contribute and sustain childhood diarrhoea prevalence in informal settlements. This information will be useful in order to control and mitigate waste-dump exposure and contact of bacterial pathogens which predominantly result from improper or mismanagement of household waste and open defecation practices among the study populations.

Note should be taken that the constituents of waste dumps varied within and across all six study locations. Numerous studies have identified DEC pathogens in various media including greywater (Winward *et al*. 2008: 191; O'Toole *et al*. 2012: 4305), sewerage and wastewater (Avery *et al*. 2005: 817; Anastasi *et al*. 2010: 5884; Salem *et al*. 2011: 150; Anastasi *et al*. 2012: 5536), stormwater (Govender, Barnes and Pieper 2011: 7), rainwater (Kaushik and Balasubramanian 2012: 136), ponds and river water (Lamprecht *et al*. 2014: 3; Ndlovu *et al*. 2015: 7) and soil (Brennan *et al*. 2010: 2176). van Eslas *et al*. (2011: 176) explained that there is a strong probability of migration of DEC strains between these habitats and media, hence childrens' waste-dump exposure by direct contact, ingestion, inoculation and airborne transmission within the six study settings is both conceivable and highly probable.

Additionally, pests such as flies, rodents and cockroaches were observed within and amongst the waste dumps and numerous studies have shown their potential and significance as mechanical vectors of pathogenic *E.coli* (Nazni *et al*. 2005: 228; Tatfeng *et al.* 2005: 130; Tachbele *et al.* 2006: 39; Ambu 2014: 1). Domestic and stray animals including dogs, cats and

chickens that forage the waste dumps across all six settlements may also act as reservoirs of diarrhoea as have been reported in several studies (Krause, Zimmermann and Beutin 2005: 90; Salehi, Badouei and Gohari 2011: 588; Puno-Sarmiento *et al*. 2013: 679). Therefore both pests and domestic and stray animals cannot be excluded in the transmission of DEC strains to children living in these settlements.

With the exception of temperature, other parameters including oxygen, pH, soil texture, dissolved organic carbon and assessment of complex microbial community interactions were not recorded in this study. However, van Eslas *et al*. (2011: 178), indicated that these are key determinants in *E.coli* growth and death rates in open environments. Additionally, the availability of water is critical for *E.coli* survival in waste dumps and van Eslas *et al*. (2011: 179) explained that excessive or highly reduced moisture content result in destruction of these species. In the current context of low rainfall and drought-like patterns experienced across KwaZulu Natal, the assumption that waste dumps may be devoid of moisture is highly improbable as the present study observed regular disposal of greywater and sewer discharges as common practices and occurrences respectively, within these sites.

Studies have indicated that genotypic and phenotypic traits and physiology of pathogenic *E.coli* in waste dump soil is unclear, poorly understood and a combination of local, climatic and survival characteristics increases its unpredictability in this media (Baumgardner 2012: 742; van Eslas *et al*. 2011: 181). However, since DEC strains are present in most constituents of domestic waste dumps and their ability to cause diarrhoea particularly among vulnerable subpopulations via exposure and contact, coupled with 60% of households not practicing regular handwashing, it would therefore be a fair assumption to implicate these ecological reservoirs as a major contributory factor toward the high community prevalence rates recorded. DEC pathotypes have been associated with childhood diarrhoea in most African regions (Okeke 2001: 817) and this study findings are pertinent because it

highlights a very underestimated risk namely waste dumps as secondary reservoirs of childhood diarrhoea, particularly among children living in Durban's informal settlements.

Both the KABP and experimental assessments in this study constituted a cross-sectional representation amongst the six study locations between December 2014 and February 2015 and hence it was not possible to determine whether the prevalence of childhood diarrhoea was equally high, nor whether the same types and frequencies of DEC pathotypes were present in waste dumps during other seasons typically experienced in KwaZulu Natal.

Checkley *et al*. (2000: 442) and Bennett *et al*. (2012: 63) noted that weather changes and climate variability including higher rainfall and effects of *El Nino* indeed increased the incidence of community acquired diarrhoea. In contrast, Lloyd, Kovats and Armstrong (2007: 119) noted a negative association between rainfall and childhood diarrhoea. Freeman, Anderson and Sexton (2009: 951) explained that seasonal changes affected both the risk of exposure to *E.coli* pathogens present within environmental reservoirs including the transmission of these pathogens carried by human hosts.

Climatic variations and seasonal changes are highlighted as a study limitation as both phases were undertaken cross-sectionally. However the presence of DEC pathotypes, specifically, EHEC (Chin 2000: 7) which was identified across all six study locations means that children's contact and exposure to waste dumps places them at a significant and serious risk of contracting diarrhoea. It is therefore critical that practical preventative strategies to mitigate against risks related towards childhood diarrhoea be formulated and implemented among under-resourced, vulnerable and impoverished communities such as the Jadhu Place, Kennedy Road, Foreman Road, Burnwood, Lacey Road and Puntans Hill informal settlements.

This study has reiterated the views of various researchers that children living in informal settlements are disproportionately at risk of morbidity and mortality as a result of poor living and recreational environments. These environments are characterized by indiscriminate waste dumping, faecal pollution, greywater disposal and inadequate personal hygiene practices which subject this vulnerable population to reservoirs of highly pathogenic strains of *E.coli*, one of the most frequent and potent etiological agents of childhood diarrhoea worldwide. To this end, it is important to then consider personal and municipal management strategies to ameliorate diarrhoeal prevalence in this specific age group. The next chapter includes the conclusion of the study, recommendations and future studies.

5.8 STRENGTHS OF THE STUDY

- In the absence of longitudinal data, the comprehensive KABP assessment of mothers of children under-five provided baseline data of community knowledge, perceptions and opinions related to social and environmental determinants and patterns of childhood diarrhoea within informal settlements in Durban.
- It is to the author's knowledge, the first known study in the eThekwini Municipality to scientifically address the bacteriological quality of waste dumps resulting from indiscriminate household practices and in particular, identified DEC as potential etiological agents of childhood diarrhoea amongst impoverished informal communities in the greater Durban area.
- The study recommended risk reduction strategies for mothers and caregivers in an effort to prevent or reduce community-acquired childhood diarrhoea morbidity and mortality.
- The results of this study could be used as a guide in evaluating the risks resulting from inadequate waste management and the cumulative effects of indiscriminate waste dumps on human health in urban informal settlements throughout the EMA.

- Local government departments and relevant stakeholders can play an important role by initiating public-participatory programmes to reduce the cases of acute childhood diarrhoea presenting at local eThekwini Municipality PHC clinics and overall community diarrhoea prevalence.

5.9 LIMITATIONS IN THE STUDY

- Childhood diarrhoea was confirmed by only the respondents with no clinical confirmation by appropriate medical personnel.
- HIV/AIDS could be a potential confounder.
- Due to time constraints and huge financial costs associated with microbiological testing and analysis, soil samples could not be taken on a quarterly basis to possibly illustrate the effect of seasonal conditions on DEC incidence, growth, proliferation and survival within open waste dumps.
- Resource challenges also precluded nutritional and chemical analysis including moisture content, oxygen, pH, soil texture, dissolved organic carbon, turbidity, COD, ammonia, nitrate, nitrite and phosphate concentrations to examine and better understand these parameters in relation to DEC persistence and survival within the different waste dump sites.
- The high costs of laboratory consumables also precluded the bacteriological analyses of *Salmonella* species, *Shigella* species and *Vibrio cholerae* which are well known bacteriological agents of childhood diarrhoea.
- An added advantage would have been parasitological and viral profiling of the waste dumps.
- Stool samples of children were not taken for specimen analysis when visiting PHC clinics for diagnosis and treatment of diarrhoea and thus were not considered for bacteriological examination of *E.coli* isolates. This limitation precluded the following, viz:

(i) A direct correlation between diarrhoea cases and presence of *E.coli* in the 36 samples tested.

(ii) Identifying the clonal diversity or lack thereof in *E.coli* strains circulating the open waste dumps which could have linked up with stool sample data to show a linkage between exposure to open waste dumps and childhood diarrhoea episodes, and

(iii) Establishing a link between causative agent(s) isolated from stool samples and presence of identical genotype from waste dump samples which would have been more definitive.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The prevalence of childhood diarrhoea is widespread in disadvantaged communities in the developing world and similarly the high rates of this illness recorded among children under-five within informal settlements in Durban is indeed a serious public health risk and reality. Although some are prone to believe that diarrhoea is a minor illness among the general population which is usually self-limiting and may likely clear after a day or two, the reviewed literature in this study has certainly refuted this myth by providing documented evidence that diarrhoea particularly among the under-five age group kills thousands of children per day or could lead to other serious complications including dehydration and malnutrition (Nel 2010: 15; Coetzer 2013: 5; Rahman *et al.* 2014: 664; Chola *et al*. 2015: 394; Gupta *et al*. 2015: 23).

The overall aim of the study was the association between acute childhood diarrhoea and DEC present in waste dumps located within informal settlements. In order to achieve the study objectives, a two-phased strategy was used that revealed significant risk factors in the prevalence of childhood diarrhoea within the six selected study areas.

The first phase of this two-part study commenced with a KABP survey of mothers of children <5 years that provided meaningful information to better understand what they knew about transmission, symptoms, treatment and risks associated with childhood diarrhoea. Therefore, the use of the KABP survey, although limited (n = 360 respondents) for the first objective was significant as the following findings were noted:

- A vast majority of mothers and/or primary caregivers were from low socio-economic backgrounds within informal settlements increasing under-five susceptibility to childhood diarrhoea.
- Household waste and greywater disposal, method of sanitation including open defecation and children's subsequent waste-dump exposure and contact as a potential source of childhood diarrhoea.
- The KABP study also provided evidence that maternal knowledge in respect of symptoms, causative factors, treatment and management of childhood diarrhoea was high. Unanticipated was mother's beliefs that safe and hygienic disposal of faecal and domestic waste, and hygienic food preparation were potential risk factors of childhood diarhoea.

In regard to the above findings listed above, there seems to be a wide gap in understanding potential transmission pathways including children's health and safety risks from waste-dump exposure, potential pest, domestic and wild animals as zoonotic reservoirs and low levels of handwashing among children and mothers residing in informal settlements. The inability of mothers and/or primary caregivers to apply knowledge in order to eliminate environmental risks and routes of contracting childhood diarrhoea is highlighted as a major barrier in disease prevention and thus a crucial need for focussed health education among this identified group.

The second part which included an experimental study investigated whether DEC which may be found in contaminated waste-dump soil are potential contributory agents towards the incidence and high prevalence of childhood diarrhoea within the six selected informal communities. It is well documented (O'Ryan *et al*. 2010: 672) that DEC are among the most frequent and significant bacterial pathogens associated with acute diarrhoea in developing countries. Therefore, this study is pertinent in that it identified different pathotypes of *E.coli* in waste dumps which further confirmed the possible link

between DEC presence in waste-dump soil and diarrhoea prevalence among under-five children living in these settlements.

Excessive *E.coli* counts identified in the preliminary phase of soil analysis is indicative of the presence of pathogenic bacteria (McGuinness 2012: 18) within waste dumps across all six study sites. Therefore, understanding the ecological characteristics, survival and growth of bacterial agents, specifically *E.coli* species in waste dumps is extremely important to its validation as an indicator organism. Subsequent PCR analysis of the positively identified *E.coli* isolates detected four DEC pathotypes, namely enterohaemorrhagic *E.coli* (EHEC) carrying the *stx1*; *stx2*; and *eae* genes, enteropathogenic *E.coli* (EPEC) carrying the *eae* and *bfp* genes, enterotoxigenic *E.coli* (ETEC) carrying the *st* and *It genes* and enteroaggregative *E.coli* (EAEC) carrying the *agg* gene were identified in waste dumps.

The findings from the experimental study suggest that DEC pathogens were routinely identified in waste dumps across all six informal settlements and therefore represented an extremely underestimated risk as diarrhoegenic agents especially among children that play and frequent these polluted areas. The surveillance of DEC pathogens in waste dumps resulting from indiscriminate dumping in informal human settlements is largely absent in literature, therefore the recovery of four pathotypes in the present study conclude beyond doubt that these environmental sources may be considered secondary reservoirs of ‘wasteborne” pathogens. This finding highlights environmental pollution in the form of unplanned and careless household waste and greywater disposal as key factors in the transmission and spread of childhood diarrhoea in informal settlements.

The identification of EPEC is extremely concerning as certain of its serotypes have a very low infectious dose with life-threatening consequences, suggesting devastating consequences for children’s waste-dump exposure through direct contact and ingestion, dust or droplet and aerosol inhalation.

Another finding, although not specifically associated with the overall aim of study was the presence of uropathogenic *E.coli* (UPEC) carrying the *papC* and *hlyA* genes, that were recovered from waste-dump soil samples. This extra-intestinal pathotype is a frequent etiological agent of UTIs, thereby potentially exacerbating children's health risks through waste-dump exposure.

The present findings from both phases of the study provided evidence of domestic waste dumps resulting from inadequate household waste management as a secondary habitat of DEC pathotypes and mothers KABP as risk-determinants of childhood diarrhoea. Given the rapid accumulation of waste and formation and spread of dumps in informal settlements and the documented microbial risks associated with these contaminated sites, the identification of EHEC, EPEC, ETEC and EAEC pathotypes highlights a critical need to routinely evaluate these open environments as high-risk sources of childhood diarrhoea. Further, Ramamurthy and Albert (2012: 11) confirmed that currently no "ideal vaccine exists against any DEC pathotypes" and their ability to acquire new virulence determinants including multi-drug resistance means that new pathogenic *E.coli* strains may likely emerge, reiterating the need for routine surveillance in environmental waste-dump reservoirs.

In view of the above, the key findings will assist local government departments and policy makers to plan, develop and implement effective multi-faceted interventions to prevent and/or control childhood diarrhoea within the selected communities which are recommended below:

6.2 RECOMMENDATIONS

- A multi-disciplinary stakeholder meeting to critically discuss the potential of DEC as 'wasteborne' pathogens of diarrhoea and specifically to mitigate the risk of these highly infectious bacterial agents caused by indiscriminate dumping within informal settlements.
- Key findings of the study will be relayed to all CHWs, so that they are able to conscientize mothers, caregivers and community at large of the health implications of children playing within and near faecally-contaminated waste dumps. Mothers particularly, can act as catalysts to discourage open defecation and prevent children from waste-dump exposure, ensuring habitual, regular handwashing and to implement necessary measures within the household to avoid pathogenic *E.coli* contamination of food and water supplies.
- Indiscriminate dumping appears to be widely practiced and accepted by residents of informal settlements, therefore a public participation process with the affected communities can help them understand health and safety risks and consequential exposure to waste dumps. In addition focussed environmental education and training in the serious implications and need to refrain from this practice and more important that periodic joint clean-up campaigns by residents and eThekwini Municipality, clearly is not a sustainable solution. As a matter of fact, there needs to be a complete paradigm-shift and mind-set change to curb this practice.
- A number of practical "self-help" solutions have also been recommended by Armitage *et al*. (2009: 2341) whereby cost-effective solutions can be implemented to manage greywater as an "interim crisis solution" within informal settlements across South Africa. These researchers have also concluded that "greywater management cannot be considered separately from the management of stormwater, sanitation and refuse removal", therefore it is essential for local

government stakeholders to ensure that basic components of environmental sanitation are provided for settlement dwellers.

- Currently, existing waste legislation and eThekwini bylaws prohibiting illegal dumping is not extended within urban informal settlements. Going forward it may be useful to examine implementation of enforcement to prevent this serious environmental contravention as a deterrent, particularly in settlements that have adequate waste management collection services and infrastructure. Noting that every informal settlement in this study has a committee composed of community representatives who can assist with identification of transgressors, this may be a worthwhile option to pursue.

In view of the serious impacts on childhood morbidity and mortality, it is imperative that interventions and reduction strategies that may assist in mitigating risks of diarrhoea also be documented. Therefore a review of interventions and strategies that have been used in various regions to reduce transmission risks and improve childcare and better treatment among children that have contracted childhood diarrhoea is presented.

6.3 RECOMMENDED INTERVENTIONS AND STRATEGIES TO REDUCE RISKS ASSOCIATED WITH CHILDHOOD DIARRHOEA IN INFORMAL SETTLEMENTS

6.3.1 Prevention of childhood of diarrhoea

Figure 6.1 conceptualizes critical interventions including housing, water usage and supply, sanitation, hygiene and breastfeeding that can reduce childhood diarrhoea incidence and severity. Nutrition and HIV are also shown in Figure 6.1 as they are very important underlying factors, as previously discussed that increase susceptibility of childhood diarrhoea.

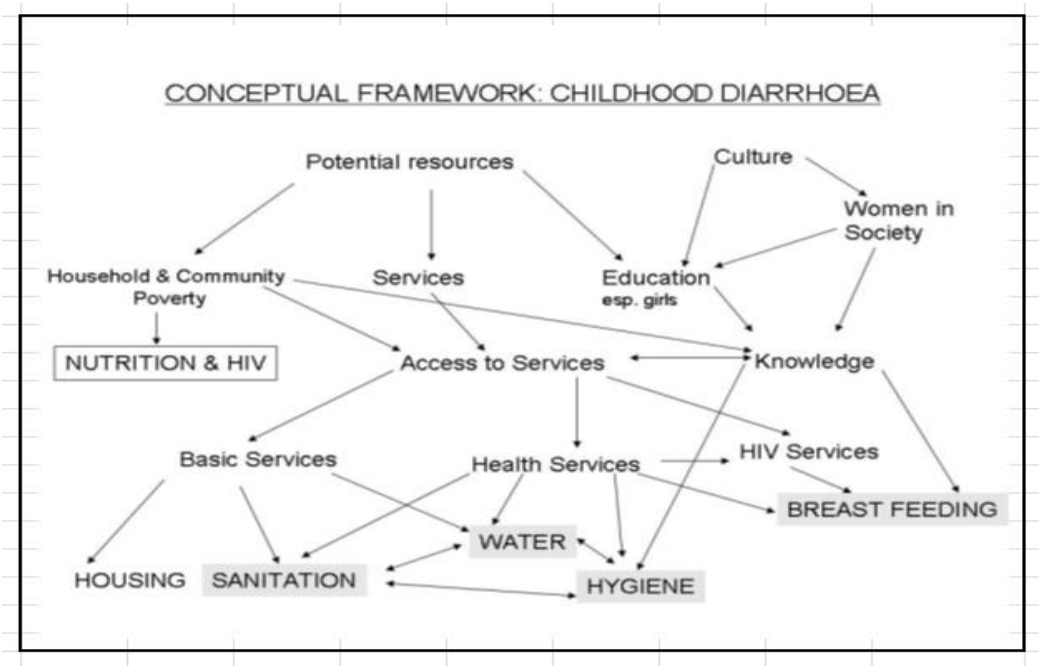

Figure 6.1: Interventions to prevent childhood diarrhoea morbidity and mortality (Sanders *et al*., 2007).

Figure 6.1 illustrates known determinants and contributing factors of childhood diarrhoea which will be further analyzed in terms of identifying prevention and control strategies that have been recommended and successfully implemented in South Africa (Sanders *et al.* 2007: 2).

6.3.2 Housing

In Durban, the eThekwini Municipality Housing Unit has drafted its informal settlement programme with a key focus on *in-situ* upgrading and to only relocate residents if such development may impact on human health and safety (eThekwini Municipality 2011: 9). However, in an email communication on 25 September 2015, Senior Manager, Housing Unit, F. Seedat indicated that the greatest challenge facing Durban, like many other African cities is the growth and increase of shacks in existing settlements and the mushrooming of new settlements within the City boundaries which places a huge burden on the local municipality to acquire land and funding necessary to improve living conditions of people living in these localities.

Therefore, in view of the major backlog with upgrading or relocating informal settlements in the eThekwini municipal area, it would be extremely critical for residents, particularly mothers and primary caregivers currently residing in these localities to be educated on the importance of breastfeeding, water, sanitation and adequate hygiene practices to reduce childhood diarrhoea.

6.3.3 Water, sanitation and hygiene

Bartram and Cairncross (2010: 01) noted that approximately 2.4 million diarrhoeal deaths worldwide could be prevented annually if all regions had adequate and equitable access to reliable sanitation, safe drinking water and practiced basic and appropriate hygiene. The reduction of this illness also requires that children have access to clean living and outdoor recreational environments and the guidance of mothers and caregivers to consistently reinforce healthy behaviour and practices (UN-HABITAT 2009: 11). Therefore mothers and primary caregivers living in the six chosen settlements must be educated on household water, sanitation and hygiene practices in order to prevent childhood diarrhoea.

According to Sanders *et al*. (2007: 7) water supply and usage are fundamental to the prevention of acute childhood diarrhoea. It is necessary for sanitation and personal hygiene, two major co-factors in the causation of this illness. Water supply includes quantity, quality (at source, after collection and storage in the household) and accessibility. Sanders *et al*. (2007: 7) also noted that whilst the World Health Organization recommended that the minimum daily supply a person needs for healthy living is 20 litres per day, in South Africa the 2004 Reconstruction and Development Programme set 50 litres per person per day as the minimum standard for drinking, food preparation, hygiene and sanitation.

According to UN-HABITAT (2009: 19), a vast majority of children in developing countries practiced indiscriminate defecation and their faeces carried a higher pathogen load than adults' and further indicated that many children frequently played in faecally-polluted living and external environments. Therefore, the provision of adequate sanitation and the education of children and primary caregivers in terms of recognizing and preventing exposure to sources, reservoirs and pathways of pathogens including DEC are key elements in the prevention of childhood diarrhoea.

There are a number of key messages that should be communicated within a health education programme related to sanitation if the critical risk factors of childhood diarrhoea are to be recognized and combatted. Naidoo, Chidley and McNamara (2008: 8) reviewed various studies and highlighted the following best practices related to sanitation, namely:

- Cleaning, sanitizing and disinfecting latrines and toilets daily and regularly;
- Adequate and safe disposal of excreta in latrines or toilets;
- Habitual handwashing after toilet usage, before eating and feeding children, food preparation, and after cleaning the bottoms of children, preferably with soap;
- Safe toilet usage that includes a safe distance from clean water supplies that are used for domestic purposes;
- As far as practical prevent domestic pets and animals from contaminating indoor living areas, water sources and ablution facilities;
- Discourage and avoiding open defecation and urination;
- Prevent contamination of food and water supplies by pests; and
- Regular maintenance of ablution facilities to prevent blockages and sewer and wastewater seepage.

In addition to safe water supply and adequate sanitation, Curtis, Cairncross and Yonli (2000: 29) explained that changes implemented to improve domestic hygiene practices at household level are highly effective in reducing the global burden of childhood diarrhoea. However, advocating vital and basic hygiene practices by encouraging behavioural change amongst children is complex as it requires sustained efforts including awareness, educational and practical training of focal target groups including mothers and primary caregivers to achieve this task. The World Health Organisation (2005: 32) advised that effective community hygiene promotion programmes should take cognizance of the following steps to enhance change in hygiene behaviours, namely:

- Build on existing status quo: A comprehensive hygiene promotion programme should first review and understand existing household practices. Thereafter the most critical hygiene risk practices must be identified and targeted by identifying people in the community who can most effectively motivate behavioural change and identifying obstacles that may prevent such change. Community members should be consulted to evaluate what works and how they are currently accessing sanitation and potable water services so that existing hygiene behaviour and practices can be effectively measured and improved on;
- Target a small number of identified risk practices: It is often impractical and costly to implement a multitude of hygiene promotion and behavioural changes in a once-off programme. Therefore priorities for hygiene behaviour change must be identified and should start with easy interventions such as promoting regular and habitual handwashing with soap by all family members after contact and safe disposal of excreta;
- Target specific community roleplayers: The community focus group may include mothers, fathers, older siblings, children, caregivers, CHWs, ward committee and informal settlement leaders. An important

group among the present study settings are mothers of young children who need to be catalysts and examples of good hygiene practices within their respective households;

- Identify the motivating criteria for changed behaviour: People may be persuaded into regular handwashing so that other community members respect them, or it enhances their pride by becoming more “health conscious” or for setting practical examples for children which could form the basis for an effective community hygiene promotion strategy; and
- Community hygiene messages must be positively reinforced: people learn and listen attentively when they laugh or are entertained whilst messages that include ‘dos’ and ‘don’ts’ can be alienating, demotivating, frustrating and demoralizing for people living in informal settlements that are poorly resourced and socio-economically deprived.

6.3.4 Breastfeeding and dietary management

A review of numerous studies has clearly indicated the benefits of breastfeeding and dietary management which also assist in the prevention, treatment and control of diarrhoea. Wittenberg (2012: 106) and WHO (2003: 7) explained that “breast milk is a hypotonic fluid that can be utilized simultaneously for hydration maintenance and feeding and breastfeeding should continue or even be increased during diarrhoea.” The World Health Organization has recommended that exclusive breastfeeding after first six months should continue with the introduction of complementary foods for normal child growth and development.

Wittenberg (2012: 106) explained that milk formulas should not be administered to children with diarrhoea owing to its high solute load and extra food should only be given after recovery. McGee (2009: 34) disputed this finding by noting that foods such as cooked rice should be encouraged as it

reduced diarrhoea severity but advised against fruit juices, sports drinks and degassed cola as suitable rehydration solution replacements.

Molla *et al*. (1989: 429) investigated the efficacy of oral rehydration therapy (ORT) in acute childhood diarrhoea based on staple foods including rice, wheat and potato compared to standard glucose-based ORT among 266 children under-five and found food-based ORT showed substantial reductions in stool output compared with the latter alternative. The study recommended that food-based ORT should be used in developing countries since the mixtures are similar to traditional weaning foods, and unlike standard ORT, it reduces stool output significantly. In cases were children become ill with diarrhoea, education of mothers and caregivers with regards to effective treatment become vitally important to reduce health impacts and fatalities.

6.3.5 Treatment of diarrhoea

A report by UNICEF/WHO (2009: 2) shows that the successful proven treatment package of childhood diarrhoea focuses on two main components, namely:

- Fluid replacement to prevent dehydration, and
- Zinc treatment.

The report explains that the administration of ORT is the basis of electrolyte and fluid replacement in children suffering with diarrhoea. Recent clinic trials have shown that low-osmolarity oral rehydration salts (ORS) is more effective at replacing fluids in children than the previous ORS formulation, and zinc treatment which decreases diarrhoea severity and duration (McGee 2009: 34). Terblanche (2010: 33) explained that zinc supplementation during acute diarrhoea significantly reduces both the duration and severity of the illness. NICUS (2005: 44) indicated that ORS with a sodium concentration less than

50-60 mmol/l is as effective as the 90 mmol/l previously recommended by WHO, and has shown to effectively reduce stool loss in children.
In South Africa, commercially available products such as Rehidrat and homemade rehydration solutions are used for the treatment of childhood diarrhoea (McGee 2009: 34).

South African treatment guidelines suggest the following formula to rehydrate a child with acute diarrhoea, namely:

- 1 litre of boiled, cooled water;
- ½ medicine measure of table salt; and
- 8 medicine measures of sugar.

The ORS should be administered with a cup and spoon in frequent, small doses, giving about 10ml/kg body weight after each loose stool until diarrhoea stops (McGee 2009: 34). However, caution against the use of antibiotics and drugs for childhood diarrhoea must be exercised. The success of any policy, health or environmental intervention for the prevention and control of childhood diarrhoea must have the buy-in and support of the targeted communities; hence community participation is critical to prevent this illness.

The above literature review has revealed and established that diarrhoea is indeed a serious and an astronomical risk of childhood morbidity and mortality in all regions of the world including South Africa.

6.4 FURTHER STUDIES

- The present study suggests further research into mothers' and children's household practices by means of an observational and KABP study whereby daily lifestyle habits including handwashing and children's method of sanitation can be risk profiled and subsequent intensive health education and promotion intervention programmes can be implemented to change, alter or amend incorrect beliefs and misunderstandings particularly in view of the serious and real threats of DEC-mediated diarrhoea. In addition mothers and caregivers understanding of the links between bacterial reservoirs and transmission in the role of infection of childhood diarrhoea must be evaluated as this was not clearly determined in the present study. Additionally, note must be taken of other confounders and their impact(s) on the study population
- The data arising from the experimental phase is of paramount importance because the surveillance of DEC pathotypes in waste dumps as secondary reservoirs are largely absent from literature. Therefore, further periodic surveillance of waste dumps should become an essential feature of public health and disease surveillance particularly in impoverished communities to assess potential health risks in more detail.
- There is a critical need to investigate the nutritional and chemical analysis including moisture content, oxygen, pH, soil texture, dissolved organic carbon, turbidity, COD, ammonia, nitrate, nitrite and phosphate concentrations in contaminated and polluted environments. These ecological characteristics may assist in understanding factors affecting DEC survival and its potential threats to public health from waste-dump exposure.
- A further study is recommended whereby stool specimens from children under-five be taken, possibly at primary health care clinics to

investigate potential links between DEC pathotypes found in waste dumps in relation to strains recovered from stool cultures.

- It is also recommended that antibiotic resistance and multi-drug resistance profiles of DEC be established as this will have a profound effect in terms of clinical examination and treatment of childhood diarrhoea caused by these etiological agents.
- Rodents, flies, cockroaches and domestic and wild animals frequenting waste dumps should also be investigated as mechanical vectors in diarrhoea transmission by examining pathogens from their faeces, vomitus and external body surfaces and linking with diarrheic agents found in childrens' stool cultures.
- It would also be important for future studies to investigate socio-economic status and limited infrastructure that inhibit the choices of informal dwellers in the management of waste and childhood diarrhoea within their communities.

It is imperative that eThekwini Municipality's Health, Water Services, Human Settlements, Solid Waste Units, ward councillors and committees take a collective leading role in combatting the spread of indiscriminate dumping to prevent waste-dump exposure, specifically as secondary reservoirs of DEC pathogens in eThekwini's informal settlements. Finally the recommendations listed in the study will only be effective in its sustained implementation and requires effort, action and mind-set changes from both community and local government stakeholders.

In an effort to attain acceptable standards of efficient and effective waste management, sanitation, and drainage, practical and cost-effective solutions must be effected and realized in the near future to ameliorate the threat posed to all children by transmission of DEC pathotypes, particularly from waste dumps owing to indiscriminate dumping. Due cognizance should be taken of these risks posed to children as the study has consistently and unequivocally showed both their physical and social development is linked to

the environment in which they grow and their susceptibility to diseases such as childhood diarrhoea - a child and community illness that can and must be prevented.

As previously discussed the study presented several limitations, therefore the results should be interpreted with caution. Notwithstanding this precaution, the findings strongly suggested DEC persistence in waste dumps as a highly probable reservoir of diarrhoea among children under-five which is extremely relevant to public health risks and surveillance and the need for prevention and control to reverse high prevalence rates among urban informal settlements.

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LIST OF ANNEXURES

Annexure A

ETHEKWINI MUNICIPALITY

HEALTH UNIT

9 Archie Gumede Place, Durban, 4001
P O Box 2443, Durban, 4000
Tel: 031 311 3523, Fax: 031 311 3530
www.durban.gov.za

Ref: 2013/01

Environmental Health Services
(Mr Preshod Ramlal)
Telephone: 311-3636
Preshod.Ramlal@durban.gov.za

2013-12-17

eThekwini Municipality
Ward 25
P.O.BOX 680
Durban
4000

Attention: Acting Head: Health (Mr N.Larratt)
Deputy Head: North (Mrs Z.Buthelezi)
Deputy Head: South (Mrs R. Van Heerden)
PHC Manager: South 4 (Mrs N. Hlope)

RE: SUMMARY OF INFORMATION AND NOTICE TO CONDUCT A 2 YEAR ENVIRONMENTAL HEALTH AND MICROBIOLOGICAL STUDY OF OPEN WASTE DUMPS FOUND IN INFORMAL SETTLEMENTS IN THE GREATER DURBAN AREA.

Dear Sir/Madam

I, Preshod Ramlal, a senior environmental health practitioner of the eThekwini Municipality Health Department has registered and embarked on a two year research study (M-Tech Environmental Health Programme) with the Durban University of Technology for the 2013 academic year [Student No: 19601850].

This correspondence aims to provide a brief synopsis report in terms of the study purpose and objectives with a view to enlighten and advise you of the potential benefit(s) and study outcomes to both the residents of informal settlements and the eThekwini Municipality Environmental Health Services Division which is mandated to ensure a safe and healthy environment to all its residents within the eThekwini Municipal area (EMA).

Title of Study: ***Prevalence of aerobic soil-transmitted bacterial pathogens of public health significance found in indiscriminate open waste dumps in informal settlements.***
Supervisor: Ms Joy Kistnasamy (DUT)
Co-Supervisor: Professor A.Olaniran (UKZN)

Background: Located within informal settlements in the greater Durban area are various indiscriminate unpermitted open waste dumpsites containing different types

of refuse and waste water in various proportions Microorganisms such as bacteria and fungi rapidly populate these waste materials using their components as sources of nutrition for growth and multiplication. Indiscriminate waste dumping therefore facilitates the uncontrolled breeding of these microorganisms and may cause a significant health hazard to the human population.

Evidence continue to emerge indicating various health risks and spread of disease associated with inadequate waste management and disposal. The presence of disease pathogens in these open dump sites found in informal settlements has not been profiled and quantified. There is also a lack of understanding and awareness of potential disease pathogens and how to reduce or mitigate such risks in order to minimise the risk to health of residents of informal settlements.

Rationale for Study: A retrospective review of clinical data obtained from three primary health care clinics (Overport, Sydenham and Clare Estate) located within the south sub-district 4 of the EMA revealed a high number of (acute) diarrhoeal cases in patients for the period 01 January 2010 to July 2013. The majority of these patients reside predominantly within six informal settlements (ie. Puntans Hill, Jadhu Place, Burnwood, Lacey Road, Kennedy Road and Foreman Road Informal settlements) which are located in the greater Durban area. Anecdotal evidence revealed a total of 617 cases of acute diarrhoea (age $\geq$ 15 years), 174 cases of acute diarrhoea (5 – 14 years) and a total of 594 diarrhoeal cases for children <5 years.

It has been recorded that patients treated at eThekwini primary health care clinics are only referred to state hospitals for stool specimen collection and analysis when they present signs of dehydration together with diarrhoeal symptoms. However, in the absence of diagnostic microbiological analysis for the above reported 1385 diarrhoeal cases, the etiology or potential reservoirs are unknown. **Hence this study will seek to investigate the prevalence of aerobic soil-transmitted bacterial pathogens found in indiscriminate open waste dumps in informal settlements as potential reservoirs of diarrhoeal disease.**

Literature Review: In a study by Vargas *et al*. (2004:536) it was reported that diarrhoea is an important cause of morbidity and mortality in children from developing countries. Children < five years of age have 3.3 diarrheic episodes per year, and > one-third of the deaths in this age group are associated with diarrhoea. Therefore, every year there are approximately 1.5 billion diarrhoeic episodes and 4 million deaths in children <five years of age caused by this disease in the developing world. In addition the main etiology of the diarrhoeal cases was related to a wide range of bacteria such as Campylobacter jejuni, Escherichia coli, Samonella species, Vibrio cholerae, Yersinia enterocolitica and Aeromonas species.

According to Lee and Puthucheary (2002:30) knowledge of the pattern of bacterial pathogens causing childhood diarrhoea in a community is important for the following reasons:

1) For health planning: to help reduce the incidence and morbidity of childhood gastroenteritis.
2) When a young child with acute diarrhoea develops extra-intestinal complications such as septicemia, awareness of the predominant bacteria causing acute diarrhoea in a community will enable early institution of appropriate antimicrobial therapy. This was evidenced by an incident in April 2013 when a six month old boy was admitted to Grey's Hospital in Kwa-Zulu Natal and had his fingers and toes amputated after a severe bout of gastroenteritis. Whilst the etiology of the gastroenteritis in this case was not known, it was important to understand that delay in treatment caused the patient to undergo hypovolaemic shock which led to the amputation of his fingers and toes to prevent gangrene) from spreading (Mchunu and Khoza 2013:5). 144

In a study by Santamaria and Toranzo (2003:5) it was concluded that soil-transmitted pathogens play an important role to the emergence of community-acquired infections contributing to the burden of communicable disease morbidity and mortality. Thus it will also be critical to collect and analyse data of community perceptions regarding indiscriminate dumping and open waste dumps as reservoirs of disease that may cause diarrhoeal disease among the study population

Research Hypothesis: The prevalence of aerobic soil-transmitted bacterial pathogens namely *Salmonella* species, *Shigella* species and diarrheagenic *E.Coli* in unpermitted, open waste dump sites located within six informal settlements in Durban is a significant contributor to acute diarrhoeal diseases.

Overall Objective: The study aims to identify three aerobic soil-transmitted bacterial pathogens from soil samples taken from open waste dump sites located within the Jadhu Place, Puntans Hill, Burnwood, Lacey Road, Foreman Road and Kennedy Road informal settlements situated in the greater Durban area. In addition, the study should provide a stimulus towards changing community perceptions that unpermitted open waste dump sites is an important cause or source of diarrhoeal infectious disease.

Specific Aims of Study

1. To identify three specific aerobic soil-transmitted bacterial pathogens (namely *Salmonella* species, *Shigella* species and diarrheagenic *E.Coli* from soil samples extracted from unpermitted open waste dump sites located within six informal settlements.

2. To investigate community perceptions of health effects and implications of unpermitted open waste dump sites including domestic waste disposal practices within the selected informal settlements.

3. To investigate any association with identified aerobic soil-transmitted bacterial pathogens and potential risk of contracting diarrhoeal diseases.

In order to meet the objectives of this project, I have accessed clinical statistics (from the Overport, Sydenham and Clare Estate Clinics) with permission from Mrs Z.Buthelezi, Mrs Vijay Naidoo and Mrs Nosipho Hlope. The questionnaires (after approval from the DUT Faculty Research community) will bear the eThekwini Logo and (if agreed upon) will be administered by community health workers already working in each of the selected settlements. Please be advised this information will be treated with utmost confidentiality and will only be used for research purposes. All participants (residents of informal settlements) will be treated as anonymous and may decline to participate in the study should they be reluctant, unsure or wish not to participate.

Potential Outcome(s) and Benefits of Study

1. To quantify soil-transmitted bacterial pathogens that are prevalent in open waste dumps and to associate possible association between acute diarrhoeal cases among residents of the selected informal settlements.
2. This will be a first research study that would investigate pathogenic bacterial loads within dump sites, thereby increasing local knowledge about public health issues and trends regarding indiscriminate waste dump sites as reservoirs of soil-transmitted diseases.

If you have any further queries, please do not hesitate to contact P.Ramlal (083 718 7143) or you may contact supervisor: Ms Joy Kistnasamy (031 373 2249).

Yours faithfully

[redacted]

P.RAMLAL
SENIOR ENVIRONMENTAL HEALTH PRACTITIONER
(B-Tech:Environmental Health, *Cum Laude*; Honours: Public Administration, *Cum Laude*)

NB. Please provide brief comment(s) on following page.

PHC Area Manager S4: Mrs N.Hlope

Comment(s): In view of the rise in diarrhoeal cases in these areas this study will be able to assist us in the prevention & proper care of the clients. I support the study fully

[redacted] r Manager
PHC South4.

Deputy Head North: Mrs Z.Buthelezi

Comment(s): This project is fully supported, It will be great to see the outcomes and results of the findings. This will assist in the interventions in vector control matters.

[redacted]

Deputy Head South: Mrs R. Van Heerden

Comment(s): Fully supported! Results should assist the [illegible] of managing health hazards in open waste dumps

[redacted]

11/02/2014

Acting Head: Health (Mr N.Larratt)

Comment(s): I fully support & Encourage EHP's to conduct Environmental Health related Research. In relation to this specific proposal I would like to make 2 Observations

1) It may add value to conduct some vector related counts in conjunction with the study

2) Stool sample analysis would add much scientific robustness, the research proposal does however note that this may not be possible.

[redacted] 17/12/2013.

Annexure B

ETHEKWINI MUNICIPALITY

HEALTH UNIT

9 Archie Gumede Place, Durban, 4001
P O Box 2443, Durban, 4000
Tel: 031 311 3523, Fax: 031 311 3530
www.durban.gov.za

Ref: 2013/01

Environmental Health Services
(Mr Preshod Ramlal)
Telephone: 311-3636
Preshod.Ramlal@durban.gov.za

2013-10-17

eThekwini Municipality
Ward 25
P.O.BOX 680
Durban
4000

Attention: Councillor Obed Bhekisane Ngcobo

RE: PERMISSION AND SUMMARY OF INFORMATION AND NOTICE TO CONDUCT A 2 YEAR ENVIRONMENTAL HEALTH AND MICROBIOLOGICAL STUDY OF OPEN WASTE DUMPS FOUND IN INFORMAL SETTLEMENTS IN THE GREATER DURBAN AREA.

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This correspondence aims to provide a brief synopsis report in terms of the study purpose and objectives with a view to enlighten and advise you of the potential benefit(s) and study outcomes to both the residents of informal settlements and the eThekwini Municipality Environmental Health Services Division which is mandated to ensure a safe and healthy environment to all its residents within the eThekwini Municipal area (EMA).

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facilitates the uncontrolled breeding of these microorganisms and may cause a significant health hazard to the human population.

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Yours faithfully

[redacted]

P.RAMLAL
SENIOR ENVIRONMENTAL HEALTH PRACTITIONER
(B-Tech:Environmental Health, *Cum Laude*; Honours: Public Administration, *Cum Laude*)

Councillor O.B.Ngcobo:
Comment(s): I SUPPORT THE INITIATIVE AND THIS STUDY WILL DECREASE THE NUMBER OF INFECTIONS IN THE INFORMAL SETTLEMENTS BUT I WOULD APPRECIATE TO RECEIVE A FINAL OUTCOME OF THE STUDY AS SOON AS IT HAS BEEN CONCLUDED.

Annexure C

MAKERERE UNIVERSITY

P. O. Box 7062 Kampala Uganda
Cables: "Makunika"

Telephone : 256 - 41 - 530686
Fax : 256 - 41 - 530686
Email : Civil@tech.mak.ac.ug

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Your Ref:

Our Ref:

To: Mr. Preshod Ramlal
Masters Student
(M-Tech Environmental Health Programme, Student no. 19601850)
Durban University of Technology
Durban, South Africa

Email: Preshod.Ramlal@durban.gov.za

1st February 2014

RE: Permission to utilize, cite and modify availed document (Questionnaire)

Following your request (letter dated 24th January 2014) in which you sought for my assistance in regard to availing you with the questionnaire that I administered in my study that sought to ascertain the local people's socio-economic status, current environmental sanitation practices and perception on various problems related to basic service provision, please find this tool attached. You do have my permission to use and modify the questionnaire as appropriate for your Masters research study.

I do hope that you find the information useful. In case of any further queries, you are welcome to consult me.

Yours Sincerely

[redacted]

Robinah N. Kulabako (PhD)
Lecturer, Department of Civil & Environmental Engineering
Email: rkulaba@tech.mak.ac.ug

Annexure D

CONFIDENTIAL

A study of childhood diarrhoea, bacteria (germs), open waste dumps, domestic waste management and knowledge, attitudes, behaviour and practices related to risk factors associated with diarrhoea.

(Ucwaningo ngesifo sohudo amagciwane,ukulahlwa kwadoti ezindaweni ezivulelekile,indlela yokuqoqa udoti,ulwazi,indlela yokuziphatha nongakwenza okuhambelana nokugwema isifo sohudo).

SECTION A: SOCIO-ECONOMIC SURVEY (INXENYE A: UMKHAKHA INHLALAKAHLE)

Date of Interview (Usuku lokubuzwa): _____ Time (Isikhathi) : _____

1. Personal details of Respondent (Imininingwane ngawe)

1.1. Name of the participant (Igama) (optional):
_____

1.2. Age of participant (Iminyaka yobudala bakho?) : _____ years

1		**18 – 24 years (18 – 24 Iminyaka)**
2		**25 - 34 years (25-34 Iminyaka)**
3		**35– 39 years (35-39 Iminyaka)**
4		**40+ years (40 + Iminyaka)**

1.3. How long have you been living in this settlement (Isikhathi osusihlalile?):

1		**< 1 year (< Unyaka owodwa)**
2		**1– 5 years (Unyaka owodwa –kuya kwemihlanu)**
3		**6 – 10 years (Iminyaka eyisthupha kuya kweyishumi)**
4		**> 10 years (>Iminyaka eyishumi)**

1.4. Gender (Ubulili): :

1		**Male (Owesilisa)**
2		**Female (Owesifazane)**

1.5. a). Are you a South African Citizen (Isakhamuzi sase South Africa?):

1		**Yes (Yebo)**
2		**No (Cha)**

b). If not a South African citizen, state country of origin (Uma ungeyena owaseMzansi Afrika, isho izwe lakho):

_____

1.6. a) What is your status in the household (Ubudlelwane bakho kulomuzi?):

1		**Mother (Ungumama)**
2		**Father (Ungubaba)**
3		**Grandparent (Ungugogo/Mkhulu)**
4		**Other (Okunye)**

b) If other, please specify (Uma ngabe ungokunye sicela usichazele khona

_____

1.7. How many occupants (including yourself) live in this household (Nibangaki enihlala kulendlu/kulomuzi kanye nawe?):

1		**1 X Occupant (Umhlall Oyedwa)**
2		**2 X Occupants (Abahlali Ababili)**
3		**3 X Occupants (Abahlali Abathathu)**
4		**4 X Occupants (Abahlali Abane)**
5		**> 5 X Occupants (Abahlali Abaningi)**

1.8. How many children live in this household (Bangakanani abantwana abahlala kulomuzi?):

1		**Between 0 – 4 years (Phakathi 0-4 Iminyaka)**
2		**Between 5 – 14 years (Phakathi 5-14 Iminyaka)**
3		**15 years and older (15 Years and older)**

1.9. Are you renting your accommodation (Uqashile yini?):

1		**Yes (Yebo)**
2		**No (Cha)**

?

1.10.
1.11.

1.10. Type of employment (Umsebenzi owenzayo?):

1		**Unemployed (Awusebenzi)**
2		**Permanent (Uqashwe Ngokugcwele)**
3		**Temporary (Awuqashwanga Ngokugcwele)**
4		**Casual (Itoho)**

?

1.11. a). What is the main source of income in this household (Indlela eniziphilisa ngayo?):

1		**Salary/Wage (Umholo wakho Wasemsebenzini)**
2		**Pension (Impesheni)**
3		**Grant (Imali Yesondlo)**
4		**Other (Enye Indlela)**

?

b). If other, please specify (Mangabe uthi okunye sicela usichazele?):

_____

1.12. What is the average monthly income in this household (Imali engenayo ngenyanga emzini wakho?):
?

1		**< R200**
2		**R200 – R500**
3		**R501 – R1000**
4		**R1001 – R1500**
5		**R1501 – R2000**
6		**R2001 – R3000**
7		**> R3000**

1.13.What is your level of education (Izinga lemfundo yakho?):

1		**None (Angifundanga)**
2		**Primary (Emabangeni aphansi)**
3		**Secondary (Phakathi nendawo)**
4		**Tertiary (Imfundo ephakeme)**

SECTION B: WATER USAGE, SANITATION, AND DOMESTIC WASTE MANAGEMENT

(INGXENYE B: UKUSETSHENZISWA KWAMANZI UKUHLANZEKA NENDLELA YOKUQOQA UDOTI)

1. Water Usage (Ukusetshenziswa kwamanzi)

1.1. a). Where do you obtain water for daily cooking, washing and cleaning (Uwathathaphi amanzi okupheka, ukuwasha, nawokuhlanza indlu?):

1		**Standpipe (Impompi yomphakathi)**
2		**Private Tap (Empompini wakwakho)**
3		**Other (Kwenye indawo)**

b). If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

1.2. a). What do you do with the (grey) water after it has been used for bathing, cooking, cleaning and washing of items(Wenzenjani ngamanzi lawa asuke esengcolile lawa asuke akade esetshenziswa mangabe kade ugeza, upheka, uhlanza indlu futhi uwasha izimpahla ngawo?):

1		**Throw into open dump (Uwalahla endaweni evulekile)**
2		**Throw into open drain (Uwalahla kumadreyini)**
3		**Re-use for gardening (Uwasebenzisa engadini)**
4		**Other (Okunye)**

b). If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

1.3. a). How and where do you store water for household purposes (Uwagcina kuphi futhi kanjani amanzi asetshenziswa layikhaya?):

1		**Plastic-Metal containers (Ezitsheni zamanzi) (Izigubhu)**
2		**Plastic-Metal drums (Emadilamini)**
3		**Other (Okunye)**

b). If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

1.4. Household water storage containers and/or receptacles are adequately cleaned, sanitised and disinfected before being utilized for storage (Lezizitsha ogcina kuzo amanzi ngabe zona zihlanzekile yini zihlanziwe ngesibulala magciwane?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

1.5. Water stored in receptacles/containers are adequately covered and free from contamination (Lamanzi asuke egciniwe asuke evaliwe futhi ngeke angene amagciwane?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

2. SANITATION (NHLANZEKO)

2.1. What type of toilet do you and the occupants of this household use every day (Hlobu luni lwendlu yangasese esetshenziswa uwe nalabo ohlala nabo endlini?):

1		**Pit Toilet (Elomgodi elisetshenziswa uma uzikhulula)**
2		**Communal Pit Toilet (Elomphakathi)**
3		**Flush Toilet (Ithoyilethe elishaywayo)**
4		**Communal Flush Toilet (Elomphakathi elishaywayo)**
5		**In or near open waste dump sites (Indawo evulelekile yokuzikhulula eduze nala ohlala khona)**
6		**Plastic toilets and disposal into waste dumps (Ithoyilethe eliyipulastiki lawa abekwayo**

2.2 Council ablution facilities are in good working order and adequately maintained which satisfy the needs of your community (Indlu yangasese kaMasipala iyawunelisa umphakathi?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

2.3 Do children play in and around areas that have been used as toilet sites (Izingane ziyadlala yini ezindaweni ezike zasetshenziselwa ekutheni zibe izindlu zangasese?):

1		**Yes (Yebo)**
2		**No (Cha)**

3 DOMESTIC REFUSE REMOVAL (UKUQOQWA KWADOTI)

3.1 How do you dispose of your everyday waste (created and collected) in your household (Uwulahlaphi udoti wansuku zonke?):

1		**To a central collection point (Endaweni lapho ulandwa khona)**
2		**In dumpsite near household (Emgodini oseduze nasendlini)**
3		**Other (Kwezinye izindawo)**

If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

3.2 a). Do you know who collects waste in your settlement (Ngabe uyazi ukuthi ngobani abalanda udoti?):

1		**DSW (DSW)**
2		**Private Collector (Inkampani ezimele)**
3		**Other (Abanye)**
4		**Don't know (Angazi)**

If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

b). How often is the waste collected (Ulandwa kangaki udoti ngakini?):

1		**Daily (Njalo)**
2		**Weekly (Ngeviki)**
3		**Fortnightly (Kweqiswa amaviki amabili**)
4		**Don't know (Angazi)**

3.3 a) When are you allocated refuse bags (Ninikwa nini oplastiki bakadoti?):

1		**Weekly (Ngeviki)**
2		**Monthly (Ngenyanga)**
3		**Don't receive (Asiwatholi)**

b). If you are in receipt of bags, how many are you allocated (Mawunikwa oplastiki bababangaki onikwa bona?):

1		**1 Refuse Bag (Owodwa plastiki kadoti)**
2		**2 Refuse Bags (Omubili plastiki kadoti)**
3		**More than 2 Refuse Bags (Ongaphezu kwemibili uplastiki kadoti)**

3.4 a). How far is the nearest designated collection or temporary storage areas/sites for solid waste in the settlement (Lingakanani ibanga eliseduze okulandwa kulo noma enibeka khona udoti okwesikhashana?):

1		**< 20 meters away (Ngokuqhelelana ngo 20 meters)**
2		**< 50 meters away (Ngokuqhelelana ngo 50 meters)**
3		**Between 50 - 100 meters away (Ngokuqhelelana phakathi kuka 50 – 100 meters)**
4		**> 100 meters away (Ukuqhelelana okungu 100 meters)**

b). Do you keep your waste bags in these designated sites for collection by DSW or other private service provider to collect (Nigcina izikhwama zodoti wenu ezindaweni enizikhandele zona ukuze abakwa dsw bazowulanda khona noma abanye benhlangano ezimele bawulanda khona?):

1		**Yes (Yebo)**
2		**No (Cha)**

3.5 a). Do you throw your domestic waste in open waste dumps in the settlement (Uyawulahla yini udoti wakho wasendlini emigodini yangakini)?

1		**Yes (Yebo)**
2		**No (Cha)**

b). If yes above, what are the main reason(s) for discarding of waste in these open waste dumps (Uma ngabe uvumile, iziphi izizathu zokuthi ulahle udoti ezindaweni ezivulekile?):

1		**Designated waste storage area situated far away from household (Izindawo okulahlwa kuzo udoti zikude nasendlini)**
2		**Designated waste storage area is too dirty (Indawo okulahlwa kuyo udoti ingcolile)**
3		**Convenient and easy to throw into nearby waste dump (Kulula futhi kungcono ukulahla kulendawo)**
4		**Everybody else in settlement does it (Wonke umuntu endaweni ulahla khona)**
5		**Other (Okunye / Kwenye)**

If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

3.6 I am satisfied with the waste removal service in this settlement (Ngiyaneliseka ngalaba abalanda udoti endaweni yangakithi):

1		**Strongly Agree (Ngiyavuma Ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

3.7 a). Are you willing to pay a monthly tariff for Council to provide an effective and efficient waste management programme in your settlement (Ngabe uyavuma ukukhokha intela ngenyanga ukhokhela umasipala ukuba anikeze izindlela zokwazi ukuhlela udoti nendlela ongalahlwa ngayo?):

1		**Yes (Yebo)**
2		**No (Cha)**

b). If yes above, how much are you willing to pay per month (Mawuthi yebo ungakhipha /khokha malini ngenyanga?):

1		**R10**
2		**R20**
3		**R30**
4		**R40**
5		**R50**
6		**>R60**

SECTION C: KNOWLEDGE, ATTITUDES, BEHAVIOUR AND PRACTICES REGARDING CHILDHOOD DIARRHOEA
(INGXENYE C: ULWAZI UKUZIPHATHA NOKWENZA MAYELANA NESIFO SOHUDO EBUNGANENI)

1. Knowledge of Childhood Diarrhoea (Ulwazi ngesifo sohudo ebunganeni)

1.1. Do you know what childhood diarrhoea is (Uyazi mayelana nesifo sohudo?) [If no, go to question 1.5] [uma ungazi ngayo iya kumbuzo 1.5]:

1		**Yes (Yebo)**
2		**No (Cha)**

1.2. If yes, what are the main symptoms of diarrhoea (Uma uvuma iziphi izimpawu zesifo sohudo?): [you may choose more than one answer] [ungakhetha noma impendulo edlule kweyodwa]:

1		**Three or more unformed stools within a day (Ukuchitha kathutha noma kaningi)**
2		**Abdominal pain (Ubuhlungu besisu)**
3		**Cramps (Inkwantshu)**
4		**Nausea (Ufisa sengathi ungaphalaza)**
5		**Vomiting (Ukuphalaza)**
6		**Fever (Ukushiselwa)**
7		**Sunken Eyes (Ukugobheka kwamehlo)**
8		**Blood in Stool (Ukopha uma uzikhulula)**
9		**Other, please specify: (Nokunye sicela ukusho)**

1.3. What do you think causes diarrhoea (Uma ucabanga yini edala isifo sohudo?) [you may choose more than one answer] [ungakhetha impendulo edlulile kweyodwa]:

1		**Germ / Bacterial infections (Amagciwane)**
2		**Indigestible foods (Ukudla okungayekanga esiswini)**
3		**Early weaning (Ukusheshe uchame)**
4		**Worm infection (Izibungu)**
5		**Dirty hands (Izandla Ezingcolile)**
6		**Prolonged breast feeding (Ukuncelisa isikhathi eside)**
7		**Other, please specify: (Nokunye sicela ukubhale)**

1.4. Is diarrhoea a serious childhood illness (Ngabe lesisifo sohudo siyinto ebucayi ngampela yini ezinganeni?):

1		**Yes (Yebo)**
2		**No (Cha)**

1.5. a) Have you ever been educated about diarrhoea (signs, symptoms, modes of transmission, prevention) (Uke wafundiswa ngesifo sohudo (izimpawu, indlela esithatheleka ngayo, nokusivikela?):

1		**Yes (Yebo)**
2		**No (Cha)**

1.5 b) If yes, through who (Mangabe uvuma wafundiswa ubani)? [you may choose more than one answer] [ungakhetha impendulo eyeqile kweyodwa]

1		**Relative (Isihlobo)**
2		**Friend (Umngani)**
3		**Health Worker (Onompilo)**
4		**Workshop (Isizinda sokufunda/sokufundiswa)**
5		**School initiatives (Eskoleni)**
6		**Radio / Television (Msakazweni/Mabonakude)**
7		**Clinic / Hospital (Mtholampilo/Sbhedlela)**
8		**Other, please specify: (Kwezinye izindawo sicela uzichaze)**

2. Practices towards Childhood Diarrhoeal Management (Ongakwenza mayelana nesifo sohudo)

2.1. When did your child (0 – 4 years) last have diarrhoea (Ugcine nini umtwana wakho ona (0-4 Imnyaka) ukuphathwa isifo sohudo?) [If more than one child, please complete boxes for child 2 and child 3] [uma ngabe kweqile maka ibhokisi lengane yesibili neyesiththu]:

Child 1(Ingane 1)

1		**One month ago (Inyanga eyodwa edlule)**
2		**Two months ago (Izinyanga ezimbili ezidlule)**
3		**Three months ago (Izinyanga ezintathu ezidlule)**
4		**Other, please specify: (Okunye sicela usicazele khona okuhlukile)**

(Ingane 3)

Child 2 (Ingane 2)

1		**One month ago (Inyanga eyodwa edlule)**
2		**Two months ago (Izinyanga ezimbili ezidlule)**
3		**Three months ago (Izinyanga ezintathu ezidlule)**
4		**Other, please specify: (Okunye sicela usicazele khona okuhlukile)**

Child 3

	One month ago (Inyanga eyodwa edlule)
	Two months ago (Izinyanga ezimbili ezidlule)
	Three months ago (Izinyanga ezintathu ezidlule)
	Other, please specify: (Okunye sicela usicazele khona okuhlukile)

2.2. How long did diarrhoea symptoms last for (Zathatha isikhathi esingakanani izimpawu?)

Child 1 (Ingane 1)

1		**1 – 3 days (1-3 Izinsuku)**
2		**4 – 7 days (4-7 izinsuku)**
3		**8 – 14 days (8-12 Izinsuku)**
4		**> 14 days (>14 Izinsuku)**

Child 2 (Ingane 2)

1		**1 – 3 days (1-3 Izinsuku)**
2		**4 – 7 days (4-7 Izinsuku)**
3		**8 – 14 days (8-14 Izinsuku)**
4		**> 14 days (> 14 Izinsuku)**

Child 3 (Ingane 3)

1		**1 – 3 days (1-3 Izinsuku)**
2		**4 – 7 days 94-7 izinsuku)**
3		**8 – 14 days 98-14 Izinsuku)**
4		**> 14 days (>14 Izinsuku)**

2.3. What do you do when your child has diarrhoea (Wenzenjani uma ngabe ingane yakho inesifo sohudo?):

1		**Do nothing (Awenzi lutho)**
2		**Go to clinic (Uya emtholampilo)**
3		**Go to (GP) (Uya okhokhelwayo)**
4		**Give oral rehydration solution (ready-made sachets) (Amathispuni awu 8 kashukela nohhafu wethispuni lika sawoti emanzini abilayo)**
5		**Prepare and give home-made fluids (Umenzela amanzi abilile owafake ushukela 8 izipuni ezincane nesikasawoti esisodwa esincane)**
6		**Use of traditional medicine (Usebenzisa amakhambi esintu)**
7		**Go to traditional healer (Uyakumelaphi wendabuko)**
8		**Other, please specify: (Okunye sicela ukuchaze)**

2.4. Was your child in contact with any other child or person that had diarrhoea before they became ill with diarrhoea (Umntwana wakho uke wahlangana nabanye abantwana noma omunye umntwana ngaphambi kokugula / kokuba nesifo sohudo?):

1		**Yes (Yebo)**
2		**No (Cha)**

2.5. Do you use homemade solutions when child has diarrhoea (Uyawusebenzisa umuthi ozenzele wona ekhaya uma ngabe umntwana wakho enesifo sohudo?):

1		**Yes (Yebo)**
2		**No (Cha)**

2.6. If yes, how do you prepare it (Mangabe uvuma uwenza kanjani?):

1		**One teaspoon of salt, eight teaspoons of sugar in one litre of water (Amathispuni awu 8 kashukela nohhafu wethispuni kasawoti emanzini abilayo)**
2		**Other (give formula): (Okunye (sicela usiphe leyondlela)**

2.7. How often do you give oral rehydration solutions (ORS) to your child (Umnika kangaki umntwana wakho ikhambi ngosuku?):

1		**After every watery stool (Ngemuva kokuchitha)**
2		**Once a day (Kanye ngosuku)**
3		**Two to three times a day (Kabili noma kathathu osukwini)**
4		**When the child wants to drink (Mangabe ingane ifuna ukuphuza)**
5		**Don't give child ORS (Awuyiniki)**

3. Attitudes towards hygiene practices and behaviour towards risks associated with childhood diarrhoea (Ukuziphatha okuphathelene nenhlanzeko, nobungozi sesifo sohudo ezinganeni)

3.1. Do you think that diarrhoea is preventable (Ucabanga ukuthi isifo sohudo singagwemeka?):

1		**Yes (Yebo)**
2		**No (Cha)**

3.2. If yes, how can it be prevented (Mangabe uvuma igwemeka kanjani?):[You may choose more than one answer] [ungakhetha impendulo eyeqile kweyodwa]

1		**Washing of hands with soap and water after getting in contact with a child's faecal matter (Ukugeza izandla ngensipho namanzi mangabe uqeda ukuphipha ingane)**
2		**Safe and hygienic disposal of faecal and domestic refuse (Ukulahla kahle inabukeni elinendle yomntwna nodoti)**
3		**Safe and hygienic food preparation (Ukulungisa ukudla ngendlela enobunono engenabo)**
4		**Other, please specify: (Okunye sicela ukuchaza)**

3.3. What type of toilet do your children use (Hlobo luni lwendlu yangasese elisebenziswa umntwana wakho?):

1		**Communal open pit latrine (Elomphakathi leli eliwumgodi)**
2		**Communal flush toilet (Elomphakathi elishawayo)**
3		**Openly defecate in or near waste dumps (Eliseduze nalana okulahlwa khona udoti eliwumgodi)**
4		**Use bed pan (Ipowa / Isikigi)**
5		**In diaper (Kuyinabukeni)**

3.4 (a) Does your child feed his or her self (Umntwana wakho uyazifunza yena?):

1		**Yes (Yebo)**
2		**No (Cha)**

(b) If yes, how does your child feed his or her self (Mangabe uvuma uzifunza ngani?):

1		**With spoon (Ngespuni)**
2		**With his / her hands (Ngesandla)**
3		**Other, please specify: (Okunye cela usibalela khona)**

(c) Do you often wash the child's hands before eating (Uyamgeza umntwana izandla ngaphambi kokudla?):

1		**Yes (Yebo)**
2		**No (Cha)**

(d) If yes, how do you treat the child's hands before eating any food (Uma ngabe uvuma umuwashisa ngani izandla phambi kokudla?):

1		**Washing with water only (Ngamanzi kuphela)**
2		**Washing with water and soap (Ngamanzi nensipho)**
3		**Other, please specify: (Okunye sicela usibalele khona)**

3.5 Do you often wash your hands (Uzihlamba kangaki izandla zakho): (please tick appropriate box) (cela ubeke uphawu ebhokisini):

		Never (angilokothi)	Sometimes (ngezinye izikhathi)	Usually (izikhathi eziningi)
1	**After going to the toilet (Mawubuya endlini yangasese)**			
2	**After helping your child defecate (Mawuqeda ukuyisa ingane edlini yangasese angizigezi ngamanye amalanga ngijwayele)**			
3	**Before eating and feeding your child (Ngaphambi kokudla nokufunza ingane angizigezi ngamanye amalanga ngijwayele)**			
4	**Before preparing food for your child (Ngaphambi kokulungisa ukudla angizigezi ngamanye amalanga ngijwayele)**			

3.6 How do you wash your hands (Uzigeza kanjani izandla?):

1		**Washing with water only (Ngamanzi)**
2		**Washing with water and soap (Ngamanzi nensipho)**
3		**Other, please specify: (Okunye ongakubhala)**

3.7 Do you think that washing your hands as stated in question 3.2 as well as “no hand-washing” for the child before eating can spread diarrhoea (Ucabanga ukuhlamba izandla ngokuchaziwe kumbuzo 3.2 njengokungahlambi izandla zengane ngaphambi kokudla kungandisa isifo sohudo?):

1		**Yes (Yebo)**
2		**No (Cha)**

3.8 Do you store cooked foods for later use (Uyakugcina ukudla okuphekiwe wenzele esinye isikhathi?):

1		**Yes (Yebo)**
2		**No (Cha)**

3.9 If yes, how do you store food (Mawuvuma ukugcina kanjani?):

1		**Refrigerator (Kwi friji)**
2		**Sealed container with lid (Esitsheni esivalwayo)**
3		**Bread / box tin (Esitsheni sesinkwa)**

3.10a) Does your children or any other children (from the settlement) play in or near the open waste dumps (Abantwana bakho bayadlala eduze nalapho kulahlwa khona udoti?):

1		**Yes (Yebo)**
2		**No (Cha)**

b). If yes above, do you believe that these children may be exposed to health and safety risks (Mangabe uvuma lokhu okungenhla ucabanga ukuthi basencupheni yokuphathwa isifo sohudo?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

3.11 a). Are there any pests (such as flies, mosquitos, mice, rodents, cockroaches) that are seen in these waste dumps (Zikhona yini izinambuzane (ezinjenge zimpukane, miyane, gundane, maphela) ezibonakalayo kulezizindawo zokulahla udoti?):

1		**Yes (Yebo)**
2		**No (Cha)**

b). These pests pose a risk to the health and safety of your family (Lezinambuzane ziyinkinga enkulu esimweni sempilo emndenini wakho yini?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

c). Briefly state what type of pests (if any) are found in and around your household (Cela usitshele kafishane ngezinambuzane ezitholakala emzini wakho)? [you may choose more than one answer] [ungakhetha noma eyeqile kweyodwa]:

1		**Flies (Izimpukane)**
2		**Mice (Amagundane)**
3		**Cockroaches (Amaphela)**
4		**Ants (Izintuthane)**
5		**Mosquitos (Omiyane)**
6		**Other (Okunye)**

If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

3.12 a). Do you own any of the following pets (Unazo izilwane kulezi ezilandelayo?) [you may choose more than one answer] [ungakhetha noma eyeqile kweyodwa]:

1		**Dogs (Izinja)**
2		**Cats (Amakati)**
3		**Poultry (Izinkukhu)**
4		**Birds (Izinyoni)**
5		**Other (Okunye)**

If other, please specify (Mawuthi kwenye indawo sicela usichazele ngayo):

_____

b). If yes above, are these pets allowed to enter, rest or sleep within your household (Uma ngabe uvuma ukuthi unazo lezilwane, ziyangena zilale noma zilala endlini yakho?):

1		**Yes (Yebo)**
2		**No (Cha)**

c). I believe that these pets can transmit disease among members of this household (Ngiyakholelwa ukuthi lezilwane zingadlulisela izifo kwamanye amalunga omndeni wami):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

d). Do your pets or other residents' pets play in and around open waste dumps in your settlement (Ngabe izilwane ezifuyiwe zidlala endaweni la kulahlwa khona udoti?):

1		**Yes (Yebo)**
2		**No (Cha)**

4 Attitudes and feeding practices towards diarrhoeal disease management (Indlela nokufunza okumayelana nesifo sohudo)

4.1 I breastfeed or breastfed my child (Ngiyamcelisa noma ngangimncelisa umntwana wami?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

4.2 I have exclusively breastfed the child in the first six months of his or her life (Ngimncelise ngakhulu ezinyangeni eziyisithupha?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

4.3 If the child is less than six months old, I am exclusively breastfeeding the child to date (Uma ngabe engaphansi kwezinyanga eziyisithupha ngizomncelisa kuze kushaye usuku?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

4.4 I know that breastfeeding adequately will reduce infections in my child (Ngiyazi ukuty uncelisa ibele kuzokwehlisa ukugula enganeni yami?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

4.5 My child has been vaccinated regularly since birth (Umntwana wami uyagoma lokhu azalwa?):

1		**Strongly Agree (Ngiyavuma ngokuphelele)**
2		**Agree (Ngiyavuma)**
3		**Undecided or Neutral (Angiqondi)**
4		**Disagree (Angivumi)**
5		**Strongly Disagree (Angivumi ngokuphelele)**

Thank You very much for participating in this study!
Siyabonga ukuthi ungenelele lolucwaningo/hlelo!

Annexure E

TRAINING OF INTERVIEWERS
Personal Focussed Workshop (one-on-one meetings and discussions) with community health workers (interviewers)

WORKSHOP

The role and responsibilities of the interviewer

The interviewer is an important link between the study participants and the research study team. This particular research study utilized the community health worker (by voluntary agreement with researcher) that live and work within the six selected informal settlements. This involved the community health worker visiting the selected participants at their homes (shack dwellings) and administering the questionnaire. The questionnaire was also translated into isiZulu for easier understanding. Each of the interviewers were required to fill in an agreement contract between themselves and the researcher.

The primary purpose and responsibility of the interviewer (community health worker) was to administer the questionnaire to the participant and ensure the accuracy of the information or data gathered. In order to do this, the interviewer had to make the participants feel comfortable so that they will share their feelings and experiences honestly and fully. This role meant that the interviewer is a crucial part of the project and had the responsibility of accurately presenting community knowledge, attitudes, beliefs and practices regarding risks to childhood diarrhoea back to the study team.

Characteristics of the fieldworker

Due to the sensitivity of some of the questions asked of participants, the interviewer needed to be an individual that is friendly, approachable, “down-to-earth” and who is capable of building a rapport with them first. Therefore selecting the community health worker already working in each of the selected settlements was indeed appropriate for the study.

The interviewer also needed to have a good understanding of the questionnaire. This was made possible during planned one-on-one personal focussed workshops on 28th November 2014 with each of the seven community health workers in which the fieldworker was explained the intent of the various questions and what would be required of them. The researcher also explained and stressed the importance of capturing the data correctly since this information will be vital to the scientific validity and accuracy of the study. Fieldworkers were requested to be friendly, polite and of sober habits and not to force people to answer the questionnaires but rather to try and convince them of the importance of answering them fully and honestly.

The researcher also stressed that fieldworkers were not allowed (under any circumstance) to divulge any information to their family, friends or people in the community during and after the fieldwork is concluded and this will also be highlighted in the agreement form (between researcher and fieldworker). In addition, they were advised that such unethical behaviour will result in immediate dismissal from the study. Interviewers were also advised to dress appropriately and use their discretion in gathering the data in an efficient and ethical manner.

It should be noted that the researcher (P.Ramlal) and environmental health officer of the eThekwini Municipality Health Unit (Mr Sipho Dlamini) did conduct two preliminary meetings with the community health workers (January and February 2014) from the Lacey Road, Puntans Hill, Jadhu Place and Kennedy Road informal settlements. The two additional community health workers assisted in the Burnwood and Foreman Road settlements. The community health workers were given a brief presentation and understanding of the study aims, purpose and objectives and from the onset, were all very eager to assist. In the actual administration of questionnaires, seven community health workers agreed to participate in the study and were also notified that written support for the study had been obtained from eThekwini Municipality Health management and the local ward councillor and ethical approval was granted by the Durban University of Technology, Faculty of Health Sciences. In addition a fee (charge rate) was also discussed for the administration of the questionnaires and as a preliminary task, each of the community health workers were given a task to conduct a door-to-door screening survey in order to identify all households that had children less than 5 years of age.

Ethics

During the personal one-on-one interviews with participants, the interviewers were not allowed to use the interviewing situation for any personal gain. They were not allowed to sell anything, or promote their own beliefs in religious, cultural, political, civic or social causes. Some of the matters discussed and agreed to include:

- only asking the respondent questions as stipulated in questionnaire
- not to give personal opinions or viewpoints with regard to any matter
- try to prompt an answer by explaining the importance of answering the question as opoosed to prompting any specific answer
- Keep interactions with participants professional.

It was important and critical that the interviewers did not stray from the interview and asked information that made the participants feel uncomfortable or was more than what was asked for in the questionnaire.

Time

The average time spent on each interview during the pilot study was approximately 45 minutes and the seven interviewers were advised that in some instances, the administration of the questionnaire may take longer to answer and they needed to exercise patience.

Before leaving the interview (participant's household), interviewers were tasked with the following:

- Make sure that all questions were answered fully and to the best of the participants' ability
- Ensure that the respondent had signed the informed consent document Which ideally must be read or read to and signed prior to commencement of the interviewing session.
- Each respondent must be thanked for their time and the valuable information that they have shared.
- The questionnaire must be signed by the interviewer and dated.

Information for the fieldworker

Each fieldworker was paid a once off agreed payment for all required completed questionnaires within each study population. The interviewers will be issued receipts upon payment for the completion of the questionnaires.

Annexure F

Letter of Agreement between researcher and interviewers

AGREEMENT

This document constitutes a written agreement in which the researcher: Preshod Ramlal has engaged you, the community health worker as an interviewer to interview the selected households, ie. mother of child (< 5 years of age) within the chosen settlement for the study. You will also be advised of the exact number of households (with children between < 5) that need to be visited and the necessary questionnaires to be administered and completed.

Fieldworkers need to conform to the following:

1. All information with regard to the questionnaire administration must be kept confidential and must not be divulged to any persons within or outside of the settlement.
2. All questionnaires must be returned as soon as they are completed.
3. Fieldworkers will be paid according to the number of completed questionnaires. They will either be paid weekly or when all the data has been completed. Receipts will be issued.
4. These questionnaires must be returned in good quality and not torn and dirty.
5. The researcher will not be liable for any harm, suffering or loss incurred by the fieldworker during the interviews.
6. Information will not be reproduced or copied in any manner.
7. Fieldworkers will be acknowledged in the dissertation.

I, the undersigned (community health worker) (state full names and surname)

……

Identity Number:……...

of…….(insert physical address)

(hereinafter called “the interviewer”

I understand and (voluntarily) agree to participate in the study with researcher: Preshod Ramlal for the purposes of the DUT Masters Research thesis and fully agree to abide by the abovementioned conditions at all times throughout the study.

Interviewer’s Signature…….. Date……

Researcher’s Signature: …… Date……

Witness Name and Signature…….

ANNEXURE G

Attachment 1: LETTER OF INFORMATION (*English copy*)

Title of the Research Study: A study of childhood diarrhoea, bacteria (germs), open waste dumps, domestic waste management and knowledge, attitudes, behaviour and practices related to risk factors associated with childhood diarrhoea.

Principal Investigator/s/researcher: (Preshod Ramlal, B-Tech: Environmental Health (*Cum Laude*), Honours: Public Administration (*Cum Laude*)

Supervisor: Ms Joy Kistnasamy (M-Tech: Environmental Health; B.Comm): Lecturer: Durban University of Technology – Department of Environmental Health)
Co-supervisor: (Phd): Professor A.Olaniran (University of Kwa-Zulu Natal – Department of Microbiology)

Brief Introduction and Purpose of the Study: You are being asked to take part in a study to determine the potential health effects of open waste dump sites found within your settlement. The purpose of the study is to find out whether your child/children suffer from diarrhoea and whether this may be caused by germs (bacteria) that may be present within the many open waste dump sites found in your settlement. If this is the case, then the study team will make recommendations to improve the situation. Your settlement was chosen because the primary health care clinic in your area has reported and recorded a high number of diarrhoeal cases in children over the past 4 years.

Selection Criteria

All households (within your settlement) that have children between 0 - 4 years of age can be part of the study. The community health worker in your settlement has previously found out exactly how many households have children between 0 – and 4 years old. Due to the large number of shacks that are present within your settlement, only a percentage of households are required to participate in this study. If you are randomly selected to participate in the study, you will be given an informed consent form and a questionnaire to fill in. Both forms are to be returned to the community health worker after the interview. You can refuse to take part or withdraw from the study at any time.

Inclusion criteria: All households that have one or more children less than five years of age will be eligible for the study. With respect to the parents of children recruited into the study, the mothers will be suitable interviewees to provide adequate information about those children and other variables surrounding the

children's environment because anecdotal evidence reveal that the mothers spend more time with their children than the fathers do. In the case where mothers are employed, community health workers will visit those adult participants after hours or over weekends. Should biological mothers be deceased or do not live with children in households, (adult) guardians will be interviewed.

Exclusion criteria: Children with following conditions were be rejected for the study: Those who were diagnosed with intestinal diseases, irritable bowel syndrome, food intolerance and those experiencing adverse medication reaction(s). All children (0 – 4years) must also reside within the selected settlement.

Procedure (Administration of Questionnaire)

If you agree to participate in this study, you will be interviewed by the community health worker of the area (settlement). You will be asked to do the following:

- Sign the attached consent form and allow the interviewer to counter sign as an adult witness.
- Allow the interviewer to read out (aloud) each question in English or isiZulu (in your preferred language).
- Answer the questions honestly and to the best of your knowledge.
- If you are uncertain about any question asked, please feel free to request the interviewer to repeat the question and/or ask the interviewer to give you a better understanding of what the question is simply trying to find out from you.
- Be patient and allow the interviewer sufficient time to fill in your answers into the questionnaire.

Risks or Discomforts to the Participant: There will be no dangers or any harm from the interview. It will be greatly appreciated if you will afford your community health worker the necessary time to interview you and complete the questionnaire.

Benefits: Your local eThekwini Health Department, community health worker and the local ward councillor will be given a written copy of the results and what they mean to you, your family and your community. If the study finds that open waste dump sites do in fact pose major health risks (such as the potential to cause childhood diarrhoea), this study will then be able to assist the eThekwini Health Department to engage with relevant stakeholders to reduce such risks within your settlement. This research project has not been conducted in Durban in the past and what we learn from this study may help to protect people, particularly children living in other informal settlements in Durban and other parts of South Africa from problems caused by careless and unnecessary waste dumping.
In addition, the researcher, P.Ramlal intend on publishing 2 research papers including an oral and poster presentation at a national or international conference.

Reason/s why the Participant May Be Withdrawn from the Study: Participation is strictly voluntary and you are free to decline to participate or to withdraw from the

study at any time should you feel uncomfortable answering any questions or do not wish to disclose specific reasons for your withdrawal. Please be advised that there are no adverse consequences should you choose to withdraw from study.

Remuneration: No gifts, hampers or money will be paid to you for participating in the study.

Costs of the Study: The study is offered at no cost to you.

Confidentiality: The information that is collected from you will be kept private and confidential. Other than the research team, this information will never be seen by anyone without your written consent. In addition, all data collected from participants will be treated as grouped and thus no individual will be identified from such documentation.

Research-related Injury: As the interviews will be conducted in the comfort of your own home and convenience, no research related injury is envisaged for you and/or your children.

Persons to Contact in the Event of Any Problems or Queries:

(Please contact the researcher (Preshod Ramlal Tel no: 083 718 7143/031 311 3636.) or my **Supervisor**: **Ms Joy Kistnasamy** : Tel (w) 031 373 2249 or email: joyk@dut.ac**.za** or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

General:

All participants are assured that participation is voluntary and that you are free to decline to participate or to withdraw from the study at any time without suffering any penalty or disadvantage. You should also be aware that a total of 360 participants from 6 informal settlements (including your settlement) will be visited and interviewed for the purposes of this research study. This letter of information is for you to keep (an isiZulu translated version is also attached).

ANNEXURE G

Attachment 2: LETTER OF INFORMATION (*isiZulu copy*)

Isiqephu L: INCWADI YOLWAZI

Isihloko socwaningo: Isifundo ngesifo sohudo,amagciwane,izindawo zokulahla ezivulekile,indlela yokunakekela ukulahlwa kadoti nolwazi ngokuziphatha no ngakwenza ukuvikela ubungozi besifo sohudo.

Umcwaningi: (Preshod Ramlal, B-Tech: Environmental Health (*Cum Laude*), Honours: Public Administration (*Cum Laude*)

Induna: Ms Joy Kistnasamy (M-Tech: Environmental Health; B.Comm): Lecturer: Durban University of Technology – Department of Environmental Health)
Isekela leNduna: (Phd): Professor A.Olaniran (University of Kwa-Zulu Natal – Department of Microbiology)

Incazelo kafushane nenhloso yokufunda: Uyacelwa ukuba ubandakanyele ocwaningeni lokubonisa ukuthi lezizindawo ezivulelekile zokulahla udoti njengemigodi ukuthi zinamthelelo muni ekufakeni izimpilo zabantu encopheni endaweni ohlala kuyo. Inhloso yalolucwaningo ukuthola ukuthi ingane/izingane zakho ziyaphathwa yini ilesisifo sohudo futhi noma ngabe lesisifo sohudo sidalwa ilamagciwane lawa asuka ezindaweni okulahlwa kuwo udoti kulendawo ohlala kuyo. Umakuyikho, ithimba lokufunda lizokwenza izincomo ukuthuthukisa isimo. Indawo yenu yokuhlala yakhethwa ngoba umtholampilo endaweni yenu yabika yaphinde yashicilela isibalo esiphezulu sesifo sohudo ezinganeni eminyakeni emithathu edlule.

INDLELA OKUKHETHWA NGAYO

Yonke imizi [endaweni ohlala kuyo] enezingane ezingaphansi kweminyaka 0-4 iminyaka ingabe inxenye yalolucwaningo. Unompilo osebenzela umphakathi walapho ohlala khona utholile ukuthi phambilini mingaki imizi enezingane ezineminyaka ephakathi ka 0-4 iminyaka. Ngenxa yokuthi miningi imikhukhu ekhona kulendawo ohlala kuyo. Kunesibalo esibekiwe esabantu abangabandakanyela kulolucwaningo. Uma ngabe nawe ukhethiwe ukuthi ubandakanyele kulolucwaningo uzonikezwa ifomu nembuzo ozoyigcwalisa omabili lamafomu kumele abuyiselwe kunompilo/mpilonhle[umbuzi] unganqaba ukuba ingxenye noma uphume kulolucwaningo noma inini.

INDLELA OKUKHETHWA NGAYO: Yonke imizi enengane noma enezingane ezineminyaka engaphansi kweyisihlanu zibalulekile kololucwaningo ngenhlonipho kubazali babantwana abangeniswe kololucwaningo, omama bazobe bengcono bebuzwa imibuzo ukuze bezokwazi ukunika ulwazi olugcwele nolubalulekile ngabantwana nokunye okubalulekile okukhungathe indawo okuhlala kuyo abantwana ubufakazi okubalulekile buyaveza ukuthi omama bachitha isikhathiesiningi nabantwana babo kunobaba. Kuloluhla lapho khona umama esuka esebenza khona umpilonhle noma unompilo uzovashela labo abangenelele ngemuva kwamahora nomangempelasonto. Uma ngabe umama womntwana kungesiye/esashona noma engahlali nabantwana kulowomuzi umqaphi womntwana[omdala] uzobuzwa yena imibuzo.

Ucwaningo Lwangaphandle: Abantwana abanalezizinkinga ezilandelayo banqatshelwe ukuthi babandakanyele kololucwaningo laba abakebaba/ batholakala benenkinga yezinso, inkinga yengqondo, abangafuni ukudla nabadla imithi zonke izingane ezineminyaka ewu 0-4 kumele babe izakhamuzi ezingeke zisuke kuleyondawo.

Inqubomgomo (Uhlalwembuzo)

Umangabe uyavuma ukungenela lolucwaningo uzobuzwa imbuzo ngonompilo wasendaweni ohlala kuyo uzocelwa ukuba wenze lokhu okulandelayo

- Usayine lelifomu elihlanganisiwe lokuvuma/elivumela lozobe ebuza imbuzo ukuba abone izimpawu njengomuntu omdala futhi nowufakazi.
- Vumela lona ozobe ebuza imbuzo ukuba akufundele imbuzo[kakhulu] umbuzo ngamunye awufunde ngesizulu noma ngesingisi [kuzoba ulimi olukhethwa uwe]
- Phendula imbuzo ngeqiniso futhi nangolwazi lwakho.
- Uma ngabe awunaso isiqiniseko ngombuzo obuzwe wona khululeka ukuba ucele lozobe ebuze ukuthi ikuphindelewona/noma cela lozobe ekubuza imbuza ukuba akucacisele umbuzo ngendlela elula futhi ozoyizwa nawe
- Iba nesineke uvumele lozobe ekubuza imbuzo futhi umnike nesikhathi esanele sokuthi agcwalise izimpendulo zakho kwembuzo azobe ekubuza yona.

Ubungozi: Akukho ukuyingcuphe noma okungalimaza kule nkulumo – mpendulo. Kuyoba into encomekayo ukuba unikeze unompilo isikhathi esanele sokulandisa kahle lenkulumo – mpendulo aze aqede.

Okuzosiza: Umasipala wangakini ethekwini Health Department kanye nonompilo nekhansela lewadi langakini bazonikezwa ikhophi ebhaliwe yemiphumela nezobe ibhalwe ukuthi bayinikwe emndenini wakho nomphakathi wakho. Mangabe lelucwaningo lithola ukuthi lezindawo zokulahla udoti ezivulekile zenza isimo sempilo singabi sihle kakhulukazi ezingane futhi zidala izifo ezinjengesifo sohudo lolucwaningo luzokwazi ukusiza i Department yezempilo ethekweni ikuba ingenelele ngokubalulekile ekuthenini kwehliswe bonke ubongozi ezindaweni zangakini. Lolucwaningo alukaze lwenziwe ethekwini phambilini futhi nesizo kufunda kololucwaningo kuzosiza ukuvikela abantu kakhulukazi izingane ezihlala kuleyondawo ethekwini nezinye izindawo okulahlwa kuzo udoti ezingenasdingo. Okunye, umcwaningi, P. Ramlal uhlose ukushicilela uncwaningo

olubili ephepheni okubalwa azoyidlulisa ngomlomo nokusebenzisa I-Poster kwi nkomfa kazwe lonke nakumazwe ngamazwe.

Isizathu/izizathu zokuthi kungani obeambe iqhaza engahoxiswa esifundweni: ukubamba iqhaza kuwukuvolontiya kuphela, kanti futhi uyakwazi ukuyeka ukubamba iqhaza noma ukuyeka ukufunda noma ingesiphi isikhathi uma uzwa ukuthi awuzizwa ungaphendula imibuzo noma ungafisi ukuveza ezinye zezizathu zokuyeka kwakho. Uyaziswa ukuthi there are no adverse consequences uma kwenzeka ukhetha ukuyeka ukufunda.

Ongakuthola: Ayikho imali ozokhokhelwa yona ngokungenela lolucwaningo

Imali ekhokhlewe lolucwaningo: Lolucwaningo alukhokhelwe lutho.

Okuyimfihlo: Lolulwazi olutholwe kuwe luzogcinwa ngaphakathi kuzoba imfihlo ngaphandle kwabethimba elihlolayo lolulwazi ngeke lubonwe muntu ngaphandle kwemvume yakho. ngaphezu kwalokho lonke ulwazi oluqoqwe kulaba abangenele kulolucwaningo lizophathwa njengamaqembu akekho ozokhonjwa.

Ucwaningo oluphathelene nokulimala: njengoba izinhlolovo zizobe zibanjwe ekhaya lakho, endaweni ekulungele, alukho ucwaningo oluphathelene nokulimala olungenzelwa wena noma izingane zakho.

Abantu ongabathinta makunezinkinga noma imibuzo:

Fonela umcwaningi (Preshod Ramlal Tel no: 083 718 7143/031 311 3636.) noma

Induna: **Ms Joy Kistnasamy**: Tel (w) 031 373 2249 or email: joyk@dut.ac**.za** or the Institutional Research Ethics administrator on 031 373 2900. Izikhalazo zingadluliselwa kuDVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

General:

Bonke ababambe iqhaza bayaqinisekiswa ukuthi iqhaza bayavolontiya nokuthi uyakwazi ukungavumi ukubamba iqhaza noma uyeke esifundweni noma ingasiphi isikhathi ngaphandle kokuhlawula noma ulahlekelwe okuthile. Fanele wazi futhi ukuth inani lababambe iqhaza elingama 338 elisuka ezindaweni eziyimijondolo (okubalwa neyakho) bazovakashelwa baphinde benziswe inhlolovo ngenhloso yalesi sifundo socwaningo. Lencwadi yolwazi ingeyakho ukuthi uyigcine.

ANNEXURE H

Attachment 1: CONSENT LETTER (*English Copy*)

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____ _____ _____ _____

Full Name of Participant **Date** **Time** **Signature / Right Thumbprint**

I, _____ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_____ _____ _____

Full Name of Researcher **Date** **Signature**

_____ _____ _____

Full Name of Witness (If applicable) **Date** **Signature**

_____ _____ _____

Full Name of Legal Guardian (If applicable) Date **Signature**

ANNEXURE H

Attachment 2: Consent Letter (*isiZulu Copy*)

ISIVUMELWANO

Isitatimende sesivumelwano sokubamba iqhaza kwi – Research Study

- Ngiyaqinisekisa ukuthi umncwanini ungazisile, _____ (Igama lomcwaningi), ngesimo, ukuziphatha, inzuzo nobungozi kwalokhu kufunda – Research Ethics Clearance Number: _____,
- Ngiphinde ngathola, ngafunda ngaphinde ngaqonda lokhu okubhalwe ngenhla (Incwadi yolwazi yobebambe iqhaza) mayelana nokufunda.
- Kukhona kimi ukuthi imiphumela yokufunda, okubandakanya imininingwane eqondene name mayelana nocansi, iminyaka, usuku lokuzalwa, uhlamvu lokuqala egameni lami kanye nokutholakele kimi kuzohlala kuyimfihlo ekwenzeni i-Study Report.
- Ukubheka okudingekayo kulolu ncwaningo, ngiyavuma ukuthi okutholakele nokuqoqiwe ngesikhathi salokhu kufunda, umncwningi angakwenza ngendlela ye- Computer
- Ngingakwazi, kunoma esiphi isigaba, ngaphandle kokubonelela, ngisihoxise isivumelwano nokubamba iqhaza esifundweni.
- Ngilitholile ithuba elanele likubuza iminuzo, (ngentando yami)ngiyafunga ngokulungela kwami ekubambeni iqhaza esifundweni.
- Ngiyakuqonda ukubaluleka kwezinto ezintsha ezitholakele ngesikhathi socwaningo okungaba nobuhlobo ekubambeni kwami iqhaza kuzokwazi kuzotholakala uma kudingeka.

_____ _____ _____ _____

Amagama aphelele **Usuku** **Isikhathi**
Sayina/Ilungelo
Thumbprint

Mina, _____(Igama lomcwaningi) ngiyaqinisekisa ukuthi obebambe iqhaza (ongenhla) wazisiwe ngokuphelele ngohlelo, ukuziphatha nobungozi besifundo esingenhla.

_____ _____ _____

Amagama aphelele oMcwaningi **Usuku** **Sayina**

_____ _____ _____

Igama eliphelele likafakazi (Uma ekhona) **Usuku** **Sayina**

_____ _____ _____

Igama eliphelele lomqaphi Osemthethweni (Uma ekhona) **Usuku** **Sayina**

ANNEXURE I: SPREADSHEET: SAMPLING DETAILS

FILE NO: PR1

DURBAN UNIVERSITY OF TECHNOLOGY

P.RAMLAL: M.TECH: ENVIRONMENTAL HEALTH PROGRAMME: 2014/2015

DATE WHEN SAMPLE TAKEN: 9 February 2015 NAME OF CONTACT PERSON: P.Ramlal

EMAIL: preshod.ramlal@durban.gov.za

TELEPHONE NO: 083 718 7143/031 3113636

DUT STUDENT NO: 19601850 ADDRESS: 9 OLD FORT PLACE, DURBAN

DATE SUBMITTED TO LABORATORY: 9 February 2015
RECEIVED BY: UKZN LAB STAFF: Ashmita/Lekita

SAMPLES OF SOIL CONTAMINATED WITH DOMESTIC WASTE - SAMPLING FOR PRESENCE OF diarrhoeagenic *E.coli* ISOLATES

NO	SAMPLE NO	NAME OF INFORMAL SETTLEMENT	LOCATION OF DUMPSITE (Latitude & Longitude Co-ordinates)	Temp^0 when sample taken
1.	KR1; KR2; KR3; KR4, KR5; KR6	KENNEDY ROAD	S29^{0}48.785' E030^{0}58.813'	KR 1 – 26.2^{0}C; KR 2 – 26.3^{0}C KR 3 - 26.2^{0}C; KR 4 – 25.8^{0}C KR 5 – 26.3^{0}C KR 6 – 25.9^{0}C
2.	FR1; FR2, FR3; FR4; FR5; FR6	FOREMAN ROAD	S29^{0}49.923' E030^{0}59.111'	FR 1 – 31.3^{0}C; FR 2 – 31.9^{0}C FR3 – 32.2^{0}C; FR4 – 31.7^{0}C FR5 – 32.3^{0}C; FR6 – 33.1^{0}C
3.	LR1; LR2; LR3; LR4; LR5; LR6;	LACEY ROAD	S29^{0}47.689' E030^{0}58.615'	LR1 – 35.2^{0}C; LR2 – 36.1^{0}C LR3 – 35.7^{0}C; LR4 – 35.8^{0}C LR5 – 35.9^{0}C; LR6 – 34.9^{0}C
4.	PH1; PH2; PH3; PH4; PH5; PH6	PUNTANS HILL	S29^{0}48.967' E031^{0}00.456'	PH1 – 31.6^{0}C; PH2 – 30.9^{0}C PH3 – 32.6^{0}C; PH4 – 31.5^{0}C PH5 – 32^{0}C; PH6 – 29.9^{0}C
5.	JP1; JP2; JP3; JP4; JP5; JP6	JADHU PLACE	S29^{0}49.226' E031^{0}00.110'	JP1 – 26.1^{0}C; JP2 – 26.3^{0}C JP3 – 26.4^{0}C; JP4 - 26.1^{0}C JP5 - 27^{0}C JP6 – 26.7^{0}C
6.	B1; B2; B3; B4; B5; B6	BURNWOOD ROAD	S29^{0}49.151' E030^{0}50.070	B1 – 31^{0}C; B2 – 29.8^{0}C B3 – 31.3^{0}C; B4 – 32^{0}C B5 – 31.5^{0}C; B6 – 32.2^{0}C

Annexure J: Composition of media, test reagents and buffers used in this study

1. Media

MRVP test medium (Biolab)	17	g/L
Nutrient agar (Biolab)	31	g/L
Nutrient broth (Biolab)	16	g/L
Nutrient gelatinase test medium (Oxoid)	128	g/L
Simmon's citrate agar (Oxoid)	23	g/L
Triple sugar iron agar (Biolab)	63	g/L
Tryptone broth (Biolab)	10	g/L

- *Alkaline peptone water*

Peptone powder (Biolab)	1	g
Sodium chloride (NaCl) (Saarchem)	1	g
Water (pH 8.6)	100	ml

2. Test reagents

- *IMViC test reagents*

Kovac's reagent

Isoamyl alcohol (Merck)	150	ml
ρ-dimethylaminobenzaldehyde (Merck)	10	g
Hydrochloric acid (HCl)	50	ml

Methyl red indicator

Methyl red (Merck)	0.05	g
95% Ethanol	150	ml

Barritt's A solution

Potassium hydroxide (KOH) (Saarchem)	40	g
Water	100	ml

Barritt's B solution

Alpha-naphthol (Merck)	5	g
Absolute ethanol	100	ml

3. Buffers

- *0.5 M Disodium ethylenediaminetetraacetate (EDTA)*

EDTA (Saarchem)	186.12	g
Double distilled water (bring up)	1000	ml
pH adjustment (sodium hydroxide pellets ~20 g)	pH 8	

- *1 M Tris-hydroxymethyl-aminomethane (Tris)*

Tris base (Roche)	121.14	g

Double distilled water (bring up)	1000	ml
pH adjustment (hydrochloric acid ~42 ml)	pH 8	

- *50 X Tris-acetate EDTA buffer (TAE)*

Tris base	242	g
Glacial acetic acid (Merck) 57.1 ml		
0.5 M EDTA (pH 8)	100	ml
Double distilled water (bring up)	1000	ml
pH adjustment (sodium hydroxide pellets/glacial acetic acid)	pH 8	

- *Phosphate buffered saline (PBS)*

Sodium chloride	8	g
Potassium chloride (KCl) (Saarchem)	0.2	g
Disodium hydrogen phosphate (Na2HPO4.12H2O) (Saarchem)	3.58	g
Potassium dihydrogen phosphate (KH2PO4) (Saarchem)	0.24	g
Double distilled water (bring up)	1000	ml
pH adjustment (hydrochloric acid)	pH 7.4	

- *Ethidium bromide stain (EtBr)*

Ethidium bromide (Sigma)	50	µl
Double distilled water	500	ml