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A COMPARATIVE STUDY OF UNDER-FIVE CHILD MORTALITY IN DIFFERENT HOUSING SETTLEMENTS IN SOWETO, SOUTH AFRICA 2002.

By

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A RESEARCH REPORT SUBMITTED TO THE FACULTY OF HEALTH SCIENCES, UNIVERSITY OF WITWATERSRAND, JOHANNESBURG IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MEDICINE) IN THE FIELD OF EPIDEMIOLOGY AND BIOSTATISTICS.

JULY 2008

DECLARATION

I, Ezekiel Sitienei Kutto hereby declare that this research report is my own unaided work. It is being submitted for the degree of Master of Science (Medicine) in the field of Epidemiology and Biostatistics at the University of Witwatersrand, Johannesburg .It has not been submitted entirely or partially for any degree or examination at this or any other university.

Signature Ezekielkutto

25th day of the Month of July year 2008

DEDICATION

I wish to dedicate this research report to my beloved wife Veronica Jepchumba Sitienei and my two beloved sons Leon and Larry for their endurance and for the moral support they gave me during the one year study period at the University of Witwatersrand in Johannesburg, South Africa.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Perinatal HIV Research Unit of the University of Witwatersrand for providing me with Soweto Household Survey data of 2002 used in this study. I trust that the findings of the study will contribute more knowledge to the scientific world in regard to under-five mortality in Soweto Townships. I also wish to extend my sincere gratitude to the funders of Soweto household survey; United States Agency for International Development (USAID).

I am profoundly grateful to my supervisors; Mr. Edmore Marinda and Helen Struthers who were available all the time for supervision, encouragement and guidance. I count myself lucky for having them as my supervisors. I also wish to thank Ronelle Van Niekerk of Perinatal HIV Research Unit for her support regarding the Soweto household survey dataset.

Finally but not least I wish to express my sincere heartfelt thanks to my course coordinator Ronel Kellerman, course administrator Lindy Mataboge, all lecturers of the school of public health and my student colleagues for their support during my study period at University of Witwatersrand.

Last but foremost I thank the almighty God for all the blessings.

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ABSTRACT

Background: The study examines the differentials in child mortality existing in the different settlements in Soweto Townships as at May 2002. It attempts to establish the association existing between housing settlement and under-five mortality and as well examine how household characteristics such as building materials, source of drinking water, sanitation facilities and source of energy is associated with under-five mortality. **Methods:** The research comprises secondary data analysis of a household survey conducted in Soweto in May 2002 by Perinatal HIV Research Unit. The aim of the study is to describe child mortality and explore its relationship to five different housing settlements in Soweto Townships. Kaplan Meier curves were fitted to examine differentials in child mortality in the different housing settlements and Log rank test was used to compare the survival curves. Logistic regression models were fitted to establish factors that were associated with under-five mortality in Soweto Townships as a whole. **Results:** A total of 2741under-five surviving children and 84 under-five deaths were studied. Informal settlements recorded the highest overall under-five mortality rate (15.9 per 10000 child years) while private sector housing settlement recorded the least (3.3 per 10000 child years) of all the housing settlements. The overall under-five mortality in Soweto Townships was 10.4 per 10000 child years. After controlling for other household characteristics settlement was significantly associated with high under-five mortality (Council settlement OR 3.3, P=0.032, 95 CI; 1.113, 10.24, Informal settlement OR 5.10, P=0.005, 95% CI; 1.633, 15.99 and Hostel settlement OR 4.09, P=0.012, 95% CI; 1.357, 12.35). Use of paraffin and candles were also significantly associated with high under-five mortality

(OR 3.4, P-value<0.001, 95% CI; 2.416, 19.15 and OR 7.2 P-value=0.014, 95% CI; 1.25, 8.88 respectively)**. Conclusions:** Private sector housing settlements reported lower under-five mortality rates in Soweto Townships (3.3 per 10,000 child years) and was less associated with high mortality in comparison to the other housing settlements (Informal, council and hostel housing settlements) in Soweto Townships**.** Use of paraffin and candles for lighting in households were mainly associated with high under-five mortality in Soweto Townships in comparison to those households that used of electricity.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

Under-five mortality rate (U5MR) is one of the most important indicators for assessing the health status of a community or a country and is a useful prerequisite for planning health interventions for child survival [1]. This indicator is linked to internationally recognised goals that countries strive to achieve in an attempt to fulfill general development standards and children's rights. Like the infant mortality rate (IMR), the U5MR provides a key baseline indication of how a country is progressing with its plan to realise children's rights, in particular their rights to life, health-care services, nutrition, education, adequate standard of living, water, social security and protection. [2]

One of the most important Millennium Development goals (MDG) developed by the United Nations is to reduce under five mortality rate by two thirds between 1990 and 2015. Their rationale is that human development cannot be sustained anywhere unless children are protected everywhere in the world [3].

High under-five mortality is mainly correlated with inadequate maternal and child health (MCH) services, insufficient nutrition, poor immunisation coverage, environmental exposure and other exogenous factors which include those related to housing conditions [4].

In many low income countries of sub-Saharan Africa, 10-20% of children die before reaching five years of age compared to high income countries, for example 0.7% in England and Wales [5].

In South Africa, it is estimated that nearly 100000 children under 5 years of age still die each year [6]. So to achieve the MDG of under-five mortality in South Africa by 2015, simply means reducing under-five deaths to lower than 67,000 a year.

HIV/AIDS is the leading cause of under-five deaths accounting for 40.3% in South Africa. Diarrhoeal disease, lower respiratory tract infections, and malnutrition, when adjusted for HIV/AIDS co-morbidity, together account for 20.3% of the under-five deaths [6].

Household characteristics such as building materials, source of drinking water, sanitation facilities and source of energy reflect economic status and are known to be important components of child survival. Together with other factors, household characteristics are thought to have direct effects on child mortality [7].

Besides reporting causes of under-five deaths, this study aims to describe child mortality and explore the differentials in under-five mortality in five different housing settlements in Soweto. It specifically aims to examine the impact housing settlement has on under-five mortality and how household characteristics such as building materials, source of

drinking water, sanitation facilities and source of energy are associated with under-five mortality.

The findings will hopefully contribute towards evaluating and developing policies regarding housing and social amenities to reduce child mortality in Soweto Townships and other Townships across the world.

1.2 BACKGROUND INFORMATION ON THE STUDY AREA

South Western Townships (Soweto) is an urban African Townships with a population estimated at 1.1 million people in 2002. Soweto is the most populous black urban residential area in South Africa. It is situated 15km to the south west of Johannesburg, Gauteng province. Soweto ranks among the poorest settlement in Johannesburg, although individual Townships tend to have a mix of wealthier and poorer residents. It hosts complex social networks and a range of socio-economic strata, with a variety of activities and lifestyles. Residents of Soweto live in dwellings ranging from low income housing such as single sex hostels and informal shack settlements to formal brick houses owned by high income earners [8].

With its high unemployment rate, the area houses many gangsters and has been a seedbed of criminal activity causing mayhem in many parts of Johannesburg [9]

Soweto was founded in the 1950's when the Africans from the freehold Townships of Alexandra, Sophia town, Martindale and Newclare were forcibly removed by the then apartheid government and rehoused in what came to be known as greater Soweto through

an accelerated housing programme for Africans. It was established to house mainly black labourers, who worked in mines and other industries in the city, away from the city centre. Soweto then became the major reception area for Africans who moved to live near the city of Johannesburg [10].

In the year 2000, it was estimated that almost two-fifths of the households were found in backyard areas with an estimated population of over 200000 people accommodated. Majority of the backyard dwellings were located behind the stands of the council houses. Council houses occupy 74% of all the stands and make up to 84% of all the formal structures [11, 20].

Soweto informal settlements are characterised by poor housing, overcrowding, and little infrastructure. Dwellings in these settlements are made of corrugated iron sheets and plastic. The informal settlements are unregulated clusters of shacks that sprout on vacant land, have been illegally settled and have minimal service provision, without electricity or running water. It is estimated that about 65,000 Sowetans live in informal settlements [10, 13]. Hostels are large buildings with units that were built on the outskirts of various Townships to house migrant workers who have historically lived on the fringes of Soweto. These hostels initially were for single workers and segregated by sex. Many thousands of people live in the hostels in very poor conditions [8, 12, and 13].

Another important housing domain in Soweto is the private sector developed houses which has grown significantly and it is estimated that about 90000 Sowetans now live in

neighborhoods where almost all the homes have been built by private developers and are characterised by good services and served with electricity [14].

1.3 PROBLEM STATEMENT

Nearly 100 countries are falling short of the goal to reduce child mortality adopted by world leaders at the United Nations' Millennium Summit in 2000 [14]. One in 12 children worldwide do not live to age five, despite the availability of proven, low-cost interventions on reducing child deaths [14]. At the end of the last decade, two thirds of Africans were living in absolute poverty. More than half still lacked safe water and 70% did not have proper sanitation. Infant mortality in Africa was 55% higher than the rest of the world's low income, developing countries [16].

In South Africa, a nation of 45 million people with the most sophisticated infrastructure on the continent, mortality rates in 2002 were at 59.6 deaths per 1000 live births. This occurred even after introduction of free health care and improved nutritional programmes and was largely attributed to pediatric HIV [18]. Antiretroviral therapy was not readily available to poor populations in Soweto during this study period [17].

It is argued that a safely built environment, including adequate housing conditions, is one of the most elemental human needs. Nonetheless, around one billion (one-sixth) of the world's population currently live in slums and are squatters. Poor settlements often lack basic health service consequently resulting in high infant and under-five mortality [18].

In South Africa it is estimated that more than eight million people lived in informal settlements in 2001, and that Johannesburg, which is the biggest urban centre in southern

Africa, had an estimated influx of 20000 new households per month, 90% of them into Soweto Townships [19]. It is estimated that 35% of households in Soweto live in settlements characterised by poor sanitation and lack of electricity [19].

Given all these grievances ranging from poor sanitation and poor housing, infant mortality and under-five mortality is undoubtedly high.

1.4 . SIGNIFICANCE OF THE STUDY

Although a number of studies have been undertaken in Soweto Townships, there are no well documented studies on the under-five mortality differential in the different housing settlements within Soweto Townships [20, 22]. Many of these studies focused on other factors not specifically under-five mortality; for example Ines Ackerl Kristensen in 2004 conducted a study on acute respiratory infections in children less than one year of age in Soweto, South Africa. She found out that crowding and socio-economic factors such as the father's education are important determinants for acute respiratory infections [20].

In addition it is still not clear, what other important factors are associated with child mortality within Soweto Townships and to what extent variations in the housing type and household characteristic contribute to under-five child death.

Global level data have been published on housing characteristic variation and child mortality, but information at country level (South Africa) is scarce. There seem to be lack of studies on the relationship between housing settlement/ household characteristics and under-five mortality in South Africa [22].

This study intends to utilise child mortality data of various housing settlements in Soweto collected during Soweto household survey by the Perinatal HIV Research Unit in 2002. This study therefore intends to determine child mortality rates estimates in the five different housing settlements in 2002 in order to understand the contribution of housing settlement to child mortality in Soweto Townships.

1.5 AIMS OF THE STUDY

The aim of the study is to describe child mortality and explore its relationship to five different housing settlements in urban Soweto Townships in 2002.

1.6 RESEARCH QUESTION

Is housing settlement associated with under-five mortality?

1.7 OBJECTIVES OF THE STUDY

1) To estimate and compare <1yr, 1-5yrs and overall (0-5yrs) child mortality rates in the different housing settlements in Soweto Townships.
2) To identify and examine housing settlement, household characteristics and other selected factors associated with child mortality in Soweto Townships.
3) To report causes of under-five death in the different housing settlements in Soweto Townships.

1.8 LITERATURE REVIEW.

Inadequate and insecure housing is a huge crisis facing the world today. The number of people living in inadequate housing has increased recently according to the United Nations Centre for Human Settlements (Habitat). It is estimate that 20 % of the world's population live in substandard housing with lack of food, little access to clean water, forced eviction, gender discrimination, poor health, unemployment and low income or no income. Children are particularly vulnerable to the impacts that these issues have and child mortality is undoubtedly high in these areas [21].

The situation is worse in sub-Saharan Africa, where 60% of urban housing units are temporary structures, and about half do not conform to building regulations [22].

Adequate housing is one of the most basic human needs and human right enshrined in international law. Housing is not just about having a roof on one's head. It is inextricably linked to safety and security, access to services, resources and economic opportunities [23].

Housing type and household characteristic factors are known to be associated with child mortality in urban and rural areas of many developing countries. Studies conducted in Malawi demonstrated that children of mothers who lived in households with no toilet facility or sourced drinking water from a well had a higher risk of dying compared to children who lived in households with flush toilet and piped water [24].

Another study undertaken in Bangladesh showed that housing conditions and access to safe drinking water and hygienic toilet facilities are the most critical determinants of child survival in urban areas [25].

Universally, there is vast literature that has focused on the determinants of under-five and infant mortality. Most of the studies have shown significant association between under-five/ infant mortality and household characteristics. For example a study conducted by Moser et al in 2004 using data from Demographic and Health Survey data from different countries to examine under-five mortality by household assets and household characteristics- such as roofing, floor materials, source of drinking water, toilet facilities and availability of electricity. The study showed increasing levels of under-five mortality in countries with lower ratios of household assets and inadequate household characteristics [27]. Furthermore a study done on Global Burden of Disease using disability-adjusted life-year (DALY) to compare death and disability from various disorders in developing and developed countries in 1990 demonstrated poor water supply and sanitation as among the greatest predictors of DALY and attributable to 6.8% of the world wide DALY [27].

Poor water supply and poor sanitation are features attributed to poor housing areas (slums and informal settlements) as opposed to developed modern houses often situated in places where they access safe water and proper sanitation systems. In a study conducted in Nairobi among slum dwellers, over 50% of the respondents indicated water and sanitation were the most pressing need [28]

Fotso et al in 2007 published a report on progress towards the child mortality millennium development goal in urban sub-Saharan Africa. The report focused on overcrowded slums and shantytowns characterised by poor environmental and sanitation conditions, poor access to basic amenities and social and health services, and poor livelihood opportunities that worsen the residents' susceptibility to various health problems. In their findings (Fotso et al) they established an inter-relation between access to safe water for drinking and decline in child mortality [29].

The importance of access to safe drinking water on child health, especially in urban areas, has been documented in many studies since diarrhoea is a major cause of death among under-five children in sub-Saharan Africa [29, 30]. Migration to urban areas has been the main fuelling factor of population growth in cities, straining existing water infrastructure and as a result underprivileged urban populations often pay exorbitant prices for unclean water, while services to wealthier groups are heavily subsidised [30].

Child mortality differentials according to water supply and sanitation in many urban areas of developing countries suggest that lack of access to piped water and toilet facilities reduce significantly the survival chances of under-five children. A study conducted in Eritrea using data collected by the Demographic and Health Survey (DHS) project in 1995 showed that the effect of household environment (water supply and toilet facility) remains substantially significant during the post-neonatal and child periods, even after adjusting for other socioeconomic variables. The study attempted to deal with the

question of whether access to piped water and flush toilet is associated with under-five mortality in urban areas of Eritrea [31].

Housing settlements are important determinants of health in urban settings as pointed out by Danielle et al study on Social Determinants Health Urban Populations in the United States of America (USA). The study recognised that industrial activity can have significant impact on cities with respect to pollution, and less expensive housing is often found in areas with less desirable physical environments. More often the underprivileged and lower income earners live in such environments. The study further concluded that the place of residence is situated within a particular social setting and that can have substantial impacts on health in terms of exposure [32].

A substantial body of literature demonstrates that poor housing can contribute to infectious disease transmission, injuries, asthma symptoms, poisoning and mental health problems both directly and indirectly. Susan et al reviewed 72 articles selected from 12 electronic databases of US interventions from 1990 to 2001 to evaluate the success of public health interventions related to housing. In the conclusion of her study she demonstrated that it is possible to design and carry out interventions that can lead to improved health by making changes in housing-related conditions [33]. Another study conducted with an aim of identifying socio-economic factors associated with mortality among cities in Japan demonstrated a positive correlation between mortality and old housing($r>0.2$) [34].

A similar study conducted among pre-school children in urban Trivandrum city, capital of Kerala showed high incidence of illness and almost six times greater risk among less than three years old children living in environmentally deprived areas. Morbidity information on each child was gathered for one year through weekly visits and recording of symptoms was done by trained investigators. The study went further to conclude that morbidity burden in Kerala, for under- three year old children is very high and is directly related to the quality of the housing environment [35].

The health risks faced by children can be traced back to their homes and schools because children spend most of their time in these places. The home environment, in particular, represents an important source of fetal and early childhood exposures to biologic, chemical, and physical agents.

The knowledge on the relationship between housing and health inequality, particularly within urban inner-city neighborhoods, has existed for a number of decades. In 1938, the American Public Health Association (APHA) identified knowledge gaps with respect to housing and health, in order to understand and evaluate better the relative effects on humans of the various problems that may exist in housing and its environment. Measuring the direct impact of housing quality on health is hitherto a challenge. In a recent study on the impact of housing on health, investigators estimated that indices of urban residential quality explained up to 25% of the variability in health status in Japan while housing quality remains an important component of health disparities in America and round the world [36].

Ignorance and difficult living conditions in the urban slums of developing world are likely to result in low health care use, hygiene awareness and lack of understanding of the origin of sickness leading to high morbidity and mortality. Children living under such conditions are at especially high risk of diseases such as diphtheria, pertussis, tetanus, measles, poliomyelitis, tuberculosis, injuries, diarrhoeal diseases etcetera.

A cross sectional survey study of 1500 households conducted in slum population of Dhaka city in Bangladesh reported death rates in households per 1000 children (0–107 months) within the last year from the interview to be 20.5 for boys and 27.0 for girls. The study noted that even with high vaccination coverage mortality and morbidity among young children remained alarmingly high indicating socio-economic, environmental and housing conditions as major drivers of mortality and morbidity [37].

Measles is known to be one of the leading killers amongst under-five children in poor and the developing countries. Measles is a major cause of child death in refugee camps and in internally displaced populations, where living conditions are extremely at risk of the development and spread of the disease. The fatality ratios in children in complex emergencies have been as high as 20%–30% [38]. Measles disease is known by medical profession as a mild disease except in populations living in extreme unfavorable conditions like those found in the developing world and particularly in the slums and complex emergency settings like the refugee camps [39].

Research conducted among Palestinian refugees in Beirut Lebanon showed an association between the presence of illness among household members and housing conditions. The association between housing conditions and the presence of illness among household members showed a significant positive gradient. Households with five to seven problems in housing were one and a half times more likely to be ill, and those with eight to fifteen problems(defined below) were twice more likely to be ill compared to households with zero to four problems [40]. Problems related to housing were classified as housing infrastructure services which included drinking water, electrical power, sewage and garbage disposal, as well as floods due to rainwater and housing conditions; the housing conditions index was based on items such as household infestation, adequate lighting, ventilation, heating, the presence of humidity and cracks in walls and ceiling[40].

Another cross-sectional study of 403 families conducted in a squatter settlement of Karachi over a two week period showed that factors significantly associated with respiratory infections among under-five included poor housing [41].

Many studies have shown associations between overcrowding at household level and mortality. Studies conducted in Stockholm, Sweden, to investigate overcrowding and the risk of measles death indicated a negative association between the overall risk of death and large household size. The findings of the study concluded that the crowding may have statistically independent effect to the risk of death from measles [42]. Another study conducted in Rio de Janeiro, Brazil, through brass methods of indirect estimation showed

residence in a shantytown (favela) as one of the major determinants of mortality among vulnerable populations in Brazil [43].

CHAPTER TWO

METHODOLOGY

2.1.0 STUDY DESIGN

The study is a cross sectional analytical study from a household survey conducted in Soweto in May 2002 by the Perinatal HIV Research Unit (University of the Witwatersrand). The main aim of the primary study was to determine the effects of adult morbidity and mortality on household welfare and children's well being. Secondary data from this survey has been used to investigate factors associated with under-five mortality in these Townships.

2.1.1 THE DESIGN OF SOWETO HOUSEHOLD SURVEY OF 2002.

The Soweto household survey of 2002 was a cross-sectional household survey that was stratified and two stage cluster sampling used. A total of 4912 households were surveyed and detailed information on 22724 individuals was obtained.

The survey process was carried out in two phases. In the first phase 4501 households with children under the age of 16 years were surveyed, while the second phase comprised 411 households with no children under the age of 16 years. The respondents of the study were caregivers in the household or head of the household.

Stratification was based on the type of housing; *Council houses* (these were houses formally owned by the council, leased and currently owned by the lesser), *private sector houses* (privately owned housing estates developed by the formal private construction),

b*ackyard dwellings* (rooms built in the backyard of council houses), *informal settlements houses* (temporary structures with little infrastructure otherwise called shacks).

2.1.2 QUESTIONNAIRE DESIGN AND DEVELOPMENT.

The instrument used was a modified questionnaire previously used in the Kagera survey in Tanzania and developed by the World Bank.

2.1.3 FIELD WORK

The data collection process was carried in two phases. The first survey was conducted in May and June 2002 and the second survey was conducted in October 2002 with the use of the same instrument.

2.1.4 DATA ENTRY PROCESS

Data was entered in Microsoft Access, relational database software. Quality control measures were implemented starting from the questionnaire, in the field and during data entry process.

2.2 STUDY POPULATION AND SAMPLE SIZE

The study population consisted of all children who were five-years or younger between May 1998 and May 2002.Two thousand eight hundred and twenty five children (2825) who were 5 years or younger (between 1998 and 2002) from 4501 households were included into this study.

2.3 KEY WORDS

- *Housing settlement* - refers to the type of house structure and area where people live.

- *Under-five mortality Rate (U5MR)* - is the probability (expressed as a rate per 1000 live births) of a child born in a specified year dying before reaching the age of five.

- *Infant Mortality Rate (IMR)* - refers to the number of children dying under one year of age divided by the number of live births that year. The infant mortality rate is also called the infant death rate.

2.4.0 EXPLANATORY VARIABLES

The study utilised available variables in Soweto household survey dataset. The explanatory variables included Housing settlement and household characteristics. Housing settlement stratified into five strata namely: Hostel settlements, informal settlements, backyard dwellings, council houses settlement and privately owned houses. Household characteristic included type of housing building materials, source of drinking water, toilet facilities, number of living rooms and source of energy for cooking.

2.4.1 OUTCOME VARIABLES

The outcome variable used in the study is child death or mortality. The under-five mortality rates were estimated within the different housing settlements to ascertain which settlement had the highest impact on child mortality and compared with the children who

survived during the same period. In addition the infant mortality rate (deaths within the first year of life), one to five year (1-5yr) child mortality rates and overall (0-5) child mortality rates were estimated and reported in the different housing settlements.

2.5 ETHICAL CONSIDERATIONS

Permission was obtained from the Perinatal HIV Research Unit (PHRU) of the University of the Witwatersrand to use the data of the Soweto Household cross-sectional survey of 2002. For the purpose of this research ethical clearance was obtained from the University of the Witwatersrand committee for Research on Human subjects. Data obtained was maintained in confidence and used specifically for purposes of this research.

2.6 DISSEMINATION AND UTILISATION OF THE FINDINGS.

The study upon completion will be revised, written up and published. It is expected that at least an article out of this project will be published in a Southern Africa peer review journal of Epidemiology.

The findings of the study are also anticipated to be presented to various policy makers on sectors such as housing, water and sanitation, construction industry, energy etc so as to guide them in policy decision making process.

2.7.0 DATA MANAGEMENT

A number of variables relevant to the researcher for analysis purposes were selected and variables that were not useful to the researcher were dropped. Microsoft Access was used to manage data. Observations that were not meaningful for analysis such as those that

represented refusal, not applicable and don't know were set to missing. The study at the end utilized information of a total of 2741 under-five children who were alive and 84 children who died in families living in Soweto Townships as at may 2002.

2.7.1 DATA ANALYSIS

Data analysis was carried out in Intercool Stata (Version 9). The first part of the results section gives a description of study participants in terms of distribution by housing settlements, sex and age distribution for under-five children reported to be alive in Soweto Townships as at May 2002 and under-five children who died in Soweto Townships between 1998 and 2002. Person time analysis was used to determine child mortality rates in each of the housing settlement. Log Rank test was used to compare survival curves between the different housing settlements.

Kaplan Meier Survival curves were used to describe the survival pattern of under-five children between 1998 and 2002. To investigate the association between child mortality and housing settlement, univariate and multivariate logistic models were used. Interaction between housing settlement and household characteristics was investigated as well.

CHAPTER THREE

RESULTS OF THE FINDINGS

3.1 DESCRIPTION OF THE STUDY POPULATION IN SOWETO TOWNSHIPS

The largest age category of the children in this study (**Table: 1.0**) were aged between three and five years 1074 (38%) while the least category were aged between one and two years 524(18.6%). The mean age was 24.9 months (std 15.44).The distribution in terms of age categories in the various settlements was statistically significantly different (P-value=0.006, chi2= 27.81). There were about as many boys as girls among children who were alive at the time of data collection in 2002.There were 1,323 (48.3%) males and 1,418 (51.7%) females. However sex was not recorded for those children who were reported to have died before their 5th birthday during the survey. A larger number of children, 64 (22.2%) lived in the Backyard housing settlement and the least 15.7% (443) lived in private sector housing settlement (**Table 1.0**). Distribution of these children in the settlements was statistically significantly different (P-value<0.05, chi2=9.34).

Table 1.0: Description of the study population in Soweto Townships

Variable	category	Frequency (%)
Housing settlement		
	Informal	543(19.2%)
	Council	618(21.9%)
	Backyard	624(22.2%)
	Hostels	597(21.1%)
	Private sector	443(15.7%)
	Total	**2825(100%)**
Age(Months)		
	0-12	693(24.5%)
	12-24	524(18.6%)
	24-36	534(18.9%)
	36-60	1074(38.0%)
	Total	**2825(100%)**
Sex(Children alive)		
	Males	1324(48.3%)
	Females	1417(51.7%)
	Total	**2741(100%)**

3.2 HOUSEHOLD CHARACTERICTICS BY HOUSING SETTLEMENT IN SOWETO TOWNSHIPS.

Under-five mortality have been greatly associated with household characteristics- such as roofing, floor materials(building materials), source of drinking water, toilet facilities and availability of electricity [27] .Further studies have shown that sanitation conditions, poor access to basic amenities and social and health services opportunities worsen the human susceptibility to various health problems [29]. It is therefore imperatively important to look at distribution of these characteristics in Soweto Townships.

All the houses in private sector housing settlement were built of brick (100 %; n=443) while backyard settlements had the least number of houses built of bricks (6.3%; n=122). Council, Informal and hostel housing settlements had 90.8 % (561), 55% (298) and 87.6% (522) respectively built of bricks. At the same time backyard settlements had the highest number of houses made of corrugated iron sheets (58.3%; n=493). Informal settlements had the highest number of housing made of temporary structures (44.8%; n=231). There was statistically significant differences in the type of building material used in the settlements (P-value <0.0001)

All the houses (100 %; n=443) in private sector housing settlement had flush toilets. Over 96% of the council and hostels houses housing settlements also had flush toilets. Less than (36.8%) of the houses in the Backyard and informal settlement had flush toilets. Majority of the toilet facilities available in the backyard settlements were the traditional pit latrine type (84.9%). There were statistically significant differences (p-value < 0.0001) in the distribution of toilet facilities types among the 5 settlements.

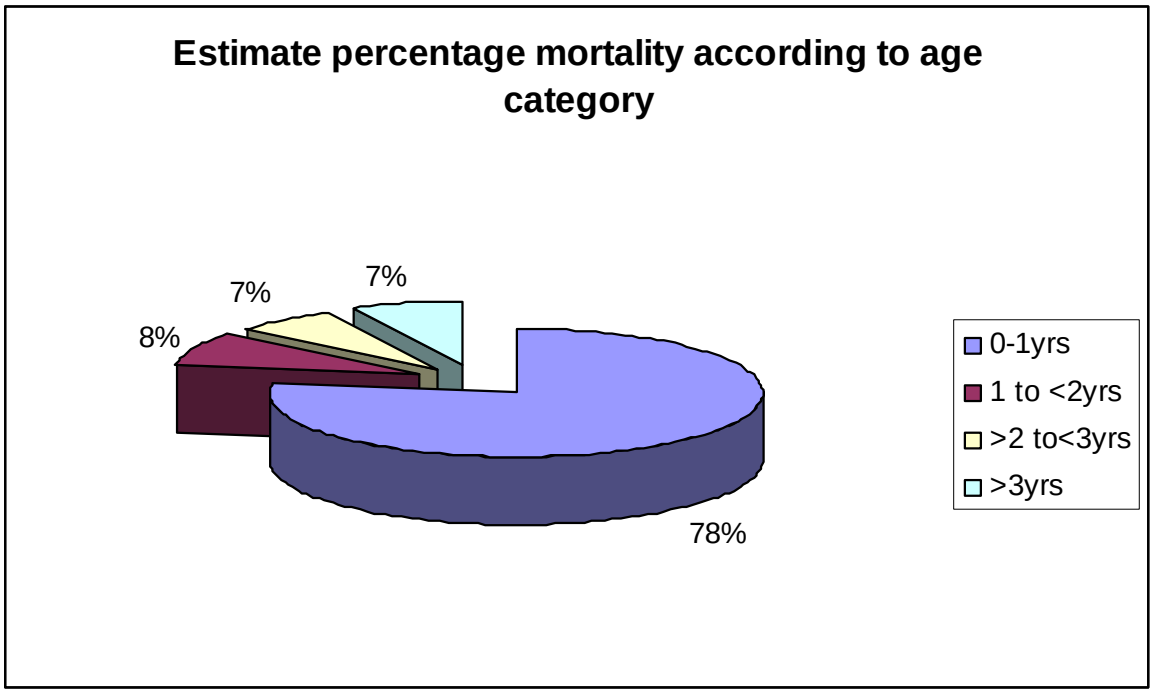
Most of the houses in the private sector had piped water inside the house 423(95.5%) and the remaining 20(4.5%) had water piped into the yard. Only 47(7.9%) of the backyard dwellers had piped water in their houses. The majority of dwellers in backyard settlements 328(79.49%) had their sources of water from public taps. Sixty seven percent (365) of the informal settlement dwellers had water piped in to the yard. There was significant difference in the distribution of type of water source in the different settlements (P-value <0.0001)

With regard to sources of energy, all housing settlements except backyard had over 95% of the sources of energy either as electricity or solar. Majority of the Backyard dwellers 253(40.7%) used paraffin as source of energy for lighting. Informal settlements had the highest number of single room houses 374(40.5%) while the private housing sector had the lowest 4(0.4%). Council, Hostel and Backyard settlements had 8.6%, 21.2% and 29.3% of houses with single rooms.

3.3 ESTIMATED PROPORTION OF UNDER-FIVE MORTALITY IN SOWETO TOWNSHIPS

The study comprised a total of 2825 children reportedly born in Soweto Townships between January1998 and May 2002 when the survey was undertaken. Of these 2.97% (84) were reported to have died before their 5th birthday **(Figure 1).** The majority of deaths among these children (77%) happened in the first year of life. The mean age at death was about 8 months.

Figure 1: Estimated percentage of under-five mortality according to age category in Soweto Townships from a cross sectional survey in Soweto 2002.



3.4 DISTRIBUTION OF THE UNDER-FIVE MORTALITY BY HOUSING SETTLEMENT.

From table 3.0 below, Under-five deaths appear to be statistically different among the housing settlements in Soweto Townships (P-Value<0.05; chi2 =9.43). Most of the under-five deaths 26.2 %(22) were reported among hostel dwellers and the least under-five deaths were reported in privately owned brick houses 4.8% (4).

Similarly, the majority of infant deaths 27.7% (24) were reported also among hostel dwellers and lowest 3.1% (2) were reported in privately owned houses (**Table 2.0**)

Table2.0: Distribution of child mortality by housing settlement in Soweto Townships

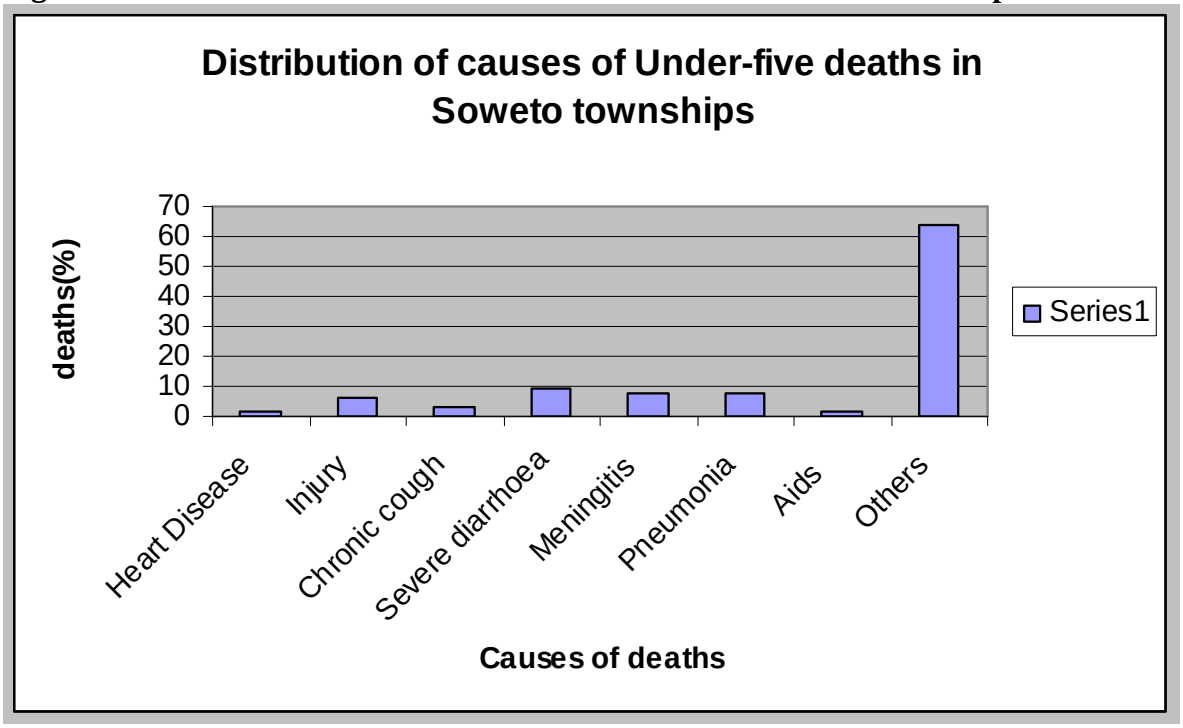
Housing settlement	Infant Deaths	1-5yr Deaths	U5Deaths
Hostels	18 (27.7%)	4 (21.1%)	22 (26.2%)
Council house	14 (21.5%)	3 (15.8%)	17 (20.4%)
Backyard	15 (23.1%)	5(26.3%)	20 (23.8%)
Informal settlements	16 (24.6%)	5 (26.3%)	21 (25.0%)
Private sector	2 (3.1%)	2 (10.5%)	4 (4.8%)
Total	**65 (100%)**	**19 (100%)**	**84 (100%)**

3.5. CAUSES OF UNDER-FIVE DEATHS IN SOWETO TOWNSHIPS

Severe diarrhoea was the most reported cause of under-five deaths and was responsible for 9.1% (6) of all the under-five deaths reported in Soweto Townships (**Figure 2.0**). Other causes of death reported included; Pneumonia 7.6% (5), Meningitis 7.6% (5), Injuries 6.1% (4), Chronic cough 3.0% (2). Aids and Heart disease were each reported to be responsible for 1.5% (1) deaths each respectively. However the majority of the under-five causes of deaths were reported as others 50.5% (47).Severe diarrhoea 5(25%) was the leading reported cause of under-five death among the children who lived in hostel settlement, while meningitis 1(5%), heart disease 1(5%) and pneumonia 1(5%) were reported least responsible for the under-five deaths in this settlement. In council housing settlement pneumonia and injuries were reported as responsible for almost a third of the under-five deaths. The causes of the other three quarters of under-five deaths were recorded as others. In the Backyard housing settlement meningitis 3(15%) was the main reported cause of under-five mortality. Pneumonia 1(5%) and Aids 1(5%) were also among the recorded causes of under-five deaths in this settlement. Chronic cough

2(15.38%) was the leading reported cause of death among under-five in informal settlements while pneumonia 1(33.3%) was reported to be responsible for a third of all the under-five deaths in private sector housing settlement.

Figure 2.0: Distribution of cause of under-five deaths in Soweto Townships



3.6 MORTALITY RATES IN THE DIFFERENT HOUSING SETTLEMENTS IN SOWETO TOWNSHIPS

Table 3.0 below shows child mortality rates in the different housing settlements in Soweto Townships. Informal settlements had the highest level of infant mortality rate (IMR) and under-five mortality rate (U5MR) while private sector housing settlement had the least mortality rate of all the housing settlements. The mortality rates reported in the above housing settlements were slightly higher for the informal and lower for the private sector housing settlements compared to the child mortality rates reported for Soweto Townships as a whole. Death rates among children aged 1-5years were higher in the

hostel housing settlements (5.2 per 10,000 child years) compared to all other housing settlements.

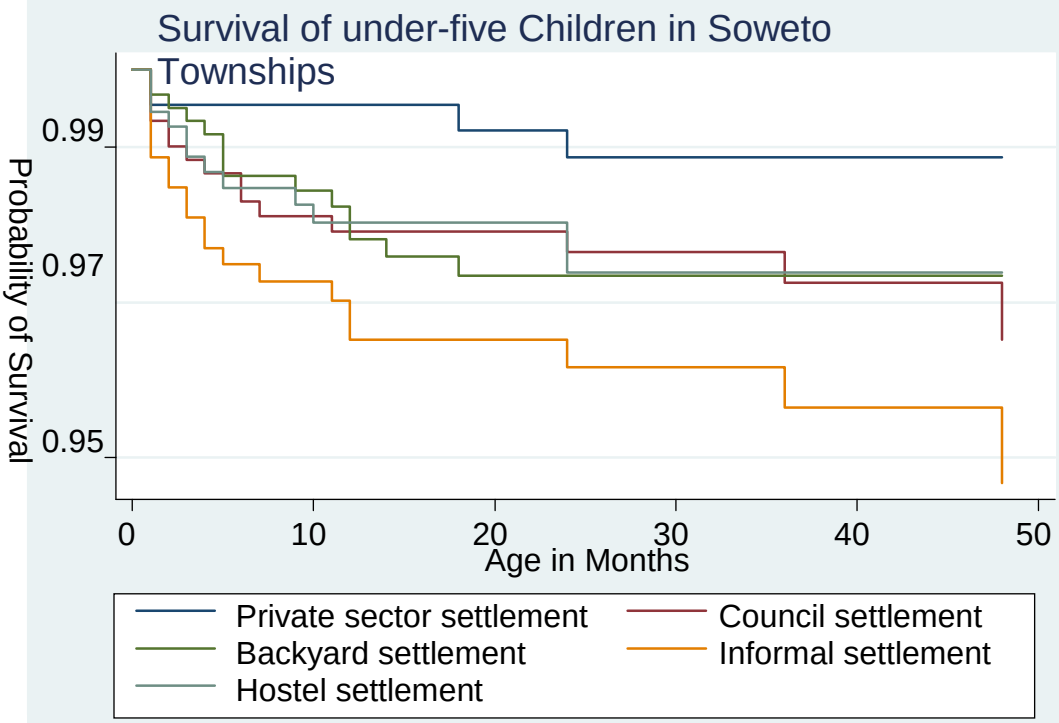
Table 3.0: Child mortality Rates in the different housing settlements in Soweto Townships

Housing settlement	Mortality Rates		
	IMR(0000)	**1-5yrMR (0000)**	**U5MR(0000)**
Hostel	2.26 CI (1.31, 3.90)	5.20 CI (2.0, 13.9)	8.90 CI (5.12, 15.83)
Council Houses	1.86 CI (1.05, 3.27)	3.20 CI (1.0, 9.8)	9.40 CI (5.7, 15.6)
Backyard	2.00 CI (1.16, 3.45)	3.40 CI (1.1, 10.4)	9.90 CI (6.3, 16.9)
Informal settlements	3.12 CI (1.94, 5.01)	4.20 CI (1.4, 13.1)	15.90 CI (10.3, 24.7)
Private sector	0.42 CI (0.11, 1.68)	2.80 CI (0.70, 11)	3.30 CI (1.3, 8.9)
Soweto Townships(overall)	1.97 CI (1.52, 2.56)	3.70 CI (2.2, 6.2)	10.40 CI (8.2, 13.1)

3.7 LEVELS OF DIFERENTIALS IN CHILD MORTALITY IN THE DIFFERENT HOUSING SETTLEMENTS IN SOWETO TOWNSHIPS.

There were statistical differences in mortality between some housing settlements in Soweto Townships **(Figure 3.0)**

Figure 3.0: Kaplan Meier under-five mortality estimate in Soweto Townships



Hostel and Private sector housing settlements showed significant differences in under-five mortality. The probabilities of survival in hostel settlement for 0-5years, 1-5years and 0-12months age categories were 97.3%, 97.4% and 98.0% respectively while in the private sector settlement the probabilities of survival for these age categories were 98.9%, 98.8% and 99.5% respectively. There were significant differences in mortality rates in the above mentioned groups in these settlements (P-values 0.013, 0.047 and 0.037 respectively). However there were no significant differences in under-five mortality rates between hostel ((8.9 per 10000child years and the other three housing settlements council houses, backyard and informal settlements –which reported under-five mortality rates of 9.4/10000, 9.9/10000 and 15.9/10000 child years respectively) P-values >0.05).

Similarly, informal and Private sector housing settlements showed significant differences in overall under-five (0-5yr) mortality (P-value=0.003). Interestingly, 1-5yr mortality (reported as 4.2/10000 and 2.8/10000child years respectively) was not significantly different (P-value=0.634 respectively). There were no significant differences in under-five mortality observed in informal settlement in relation to the backyard and council housing settlements which reported mortality of 9.9/10000 and 9.4/10000 child years respectively (P-value= 0.865).

Significant differences in overall (0-5) under-five mortality and infant mortality was observed between Backyard housing settlement which recorded mortality of 9.9/10000 child years and private sector house settlement which recorded mortality of 3.3/10000 child years (P-values=0.042 and 0.027 respectively). However there was no significant difference among the deaths of those aged between 1-5yrs (P-value=0.877) in these two settlements. Backyard and informal housing settlements which recorded mortality of 9.9/10000 and 15.9/10000 respectively, showed no significant differences in under-five mortality (P-value=0.122). The pattern of child mortality in council housing settlement did not seem to differ with those shown in all the other four housing settlements (Hostel, Backyard, informal and private sector housing settlements) which recorded under-five mortality of 8.9/10000, 9.9/10000 and 3.3/10000 child years respectively(P-value= 0.059)

3.8 FACTORS ASSOCIATED WITH CHILD MORTALITY

To examine individual effects of various explanatory variables on under-five mortality in Soweto Townships, logistic regression analyses was performed separately for each of the six variables (Univariate regression model) and then all the six variables were fitted in one model (Multivariate regression model). A number of variables showed significant association with under-five mortality. These variables include: Housing settlements and source of energy for lighting (**Table: 4.0**).

All the categories of housing settlements in the univariate model showed significant association of under-five mortality compared to private sector housing, while in multivariate models council housing settlement became non-significantly associated to under-five mortality (P-value=0.176, 95% CI 0.661, 9.58).

Children who lived in families where candles were used for lighting were significantly associated with under-five death compared to under-five children who lived in households where either electricity, gas or solar was used as a form of energy in both univariate and multivariate models. The odds of under-five deaths was 2.6 times more in univariate model and 7.2 times in multivariate model in households where candles were used compared to those household where either electricity, solar or gas was used for lighting. Households that used paraffin for cooking did not show any evidence of association with under-five mortality in univariate model (OR 1.78, 95% CI 0.98-3.23, p-value 0.058) while in multivariate model it was significantly associated with under-five mortality (P-value 0.014, OR 3.43, CI 1.25, 8.88)

Other household characteristics however did not show any evidence of association with under-five mortality in both univariate and multivariate models. These include variables such as source of drinking water, Number of household rooms, Building materials and type of toilet facilities (**See table 4.0 below**).

Table 4.0: Factors associated with under-five mortality in Soweto Townships

VARIABLE	UNIVARIATE		MULTIVARIATE	
	OR	P-value(95% CI)	OR	P-value(95% CI)
Housing settlement				
Private sector	1	- -	1	- -
Council "	3.12	0.043*(1.04, 9.29)	3.37	0.032*(1.113, 10.24)
Backyard "	3.63	0.019*(1.23, 10.71)	2.52	0.176 (0.661, 9.58)
Informal sector"	4.41	0.007*(1.50, 12.96)	5.10	0.005* (1.633, 15.99)
Hostel "	4.21	0.009*(1.44, 12.27)	4.09	0.012*(1.357,12.35)
Energy source				
Electricity	1	- -	1	- -
Paraffin	1.78	0.058(0 .981, 3.23)	3.43	0.014* (1.25, 8.88)
Candles	2.67	0.004*(1.372, 5.18)	7.02	0.001*(2.416, 19.15)
Building Materials				
Brick	1	- -		
Temporary/Mud	1.21	0.856(0.161, 9.02)		
Corrugated iron	1.11	0.654(0.698, 1.77)		
Water source				
Piped into dwelling	1	- -		
Piped into yard	1.40	0.597(0.701, 1.85)		
Public Tap	1.49	0.196(0.814, 2.73)		
No of Rooms				
Single Room	1	- -		
No. of Rooms(>1<=5)	0.720	0.150(0.461, 1.126)		
No. of Rooms(>5<8)	0.359	0.092(0.111, 1.180)		
Toilet facility type				
Flush to sewage system	1	- -		
Pit latrine	1.053	0.872(0.564, 1.965)		
No facilities/Bush	1.613	0.515(0.382, 6.801)		

Note:

***Shows significant p-values.**

All the six variables were fitted in both univariate and multivariate models.

However, only significant values were reported in multivariate model.

CHAPTER FOUR

DISCUSSION

The study has examined the differentials existing in under-five mortality in different housing settlements in Soweto Townships, South Africa during the period between 1998 and 2002. The study identified household characteristics that are associated with child mortality. It has also determined whether the type of housing settlement impacted on under-five mortality.

Severe diarrhoea was the most reported cause of under-five death in Soweto Townships and was responsible for 9.09% of all the deaths in Soweto Townships. It was responsible for a total 6 under-five deaths in informal, backyard and hostel settlements on equal ratios. This may be attributed to poor socio-amenities served to these settlements as opposed to private developed settlement which reported no death as result of diarhoea in Soweto Townships.

4.1 UNDER-FIVE MORTALITY RATES DIFFERENTIALS

The overall mortality rate in Soweto Townships was 10.4 per 10,000 child years with private sector housing settlement showing the least under-five mortality rate of 3.3 per 10,000 child years. Although overall mortality rate (0-5 years) was low compared to mortality figures reported in South Africa in 2001 for the same age group of 71 deaths per 1000 live births[18], it is likely that under-five deaths in Soweto Townships was seriously under reported because the household characteristics and housing type in some of the settlements in Soweto Townships have been found to be associated to under-five

mortality and definitely child mortality figures were undoubtedly expected to be higher than those reported above .

The findings of the study showed high under-five mortality rates in informal (15.9 per 10,000 child years) and Backyard settlements (9.9 per 10,000 child years) compared to the private sector housing settlement (3.3 per 10,000 child years). This may be attributed to wide variations in living conditions as dictated by socio-economic inequalities between these settlements. Social amenities are limited in less developed (informal and backyard where less than 36% of the households had flush toilets) settlements making under-five children more vulnerable to diseases and death. Poor housing type may also be contributing to high under-five mortality. These findings are consistent with studies conducted in Ethiopia by Abera Kumie and Yemane Berhane on crowding in a traditional home. In this study poor housing conditions was found to support the transmission of a variety of communicable diseases to the level of endemicity causing high childhood mortality [44].

The Kaplan Meier curves has clearly depicted a probability survival greater than 98% for under-five children living in private sector housing compared to those in the informal settlements which reported a probability of survival of less than 95% and backyard settlements which reported probability of survival of 97% in Soweto Townships. People in Soweto informal and backyard settlements may be affected by lack of adequate good housing and proper sanitation (Less than 55% of the houses were built of bricks and less than 36% of the households had flush toilets) as opposed to the residents of Soweto private sector housing who were served with good housing and good social amenities

(100% of the households were built of brick and had flush type of toilets). This often has a huge impact on children living in informal and backyard settlements which often is home to a wide array of infectious diseases as demonstrated in a study that was conducted among Preschool Children in Kerala [35].

The same trend has been observed in the under-five mortality rate differential between the hostel housing settlement and the private sector housing where under-five mortality is almost four fold lower in the latter. Just like informal and backyard settlements hostels housing settlements have a spectrum of problems. First, this settlement was built of single unit houses for migrant workers during apartheid regimes and now housing families with inherent resource scarcities. Secondly, it is possible that they may not be able to afford good nutritious food and other social amenities necessary for the good growth and development of a healthy child which may be the case among the dwellers in the private housing settlements.

There were no differences in the level of mortality rates between council housing settlement and private sector housing settlement. This may be attributed to the fact that this (council housing) settlement just like in the private sector housing had adequate housing built of bricks (>90%) and over 96% of the households had water piped into the homesteads.

4.2 CAUSES OF UNDER-FIVE MORTALITY IN SOWETO TOWNSHIPS

The contribution of housing settlement as dictated by environmental factors to under-five mortality has been seen in Soweto Townships (Table 4.0). Although, most of the verbal

autopsies reported causes of under-five death as “other”, severe diarrhoea, pneumonia, injury and tuberculosis commonly associated with poor environmental conditions were among the reported causes of under-five deaths in Soweto Townships. The classification of majority of causes of under-five death as ‘others’ is attributed to the fact that most symptoms for under-fives are non specific. Recall problems and stigma among the caregivers during the survey process may also explain why a lot of causes of death classifications are reported as ‘others’.

Severe diarrhoea featured predominantly as a major cause of death in hostel and backyard settlements. These settlements in Soweto Townships are replete with poor environmental factors (unclean water, public pit latrines etc) which obviously predispose children to diarrhoeal diseases and poor health outcomes. Inadequate flush toilets facilities and use of water from public taps (<36% and <40% respectively) in these settlements predispose children to infections leading to diarrhoeal diseases. These findings are consistent with the studies conducted in Kenya, which showed that children living in unsanitary conditions i.e. slum were more likely to experience diarrhoea than their counterparts in healthier neighborhoods (UN-HABITAT 2003).

Pneumonia just like diarrhoea is precipitated by poor living conditions as those found in the backyard, hostel and informal settlements in Soweto Townships. Overcrowding in hostels and council housing settlements may have contributed to the development of pneumonia which resulted in deaths among under-five.

4.3 PREDICTORS OF UNDER-FIVE MORTALITY IN SOWETO TOWNSHIPS

The results of univariate logistic regression analysis show that private sector housing settlement and source of energy for lighting were significantly associated to under-five mortality in Soweto Townships.

In univariate and multivariate models, the odds of under-five death were significantly higher for those children who lived in informal housing settlements (Univariate Model; OR 4.41, P-value 0.007, CI 1.50, 12.96 and Multivariate Model; OR 5.10, P-value 0.005 CI1.633, 15.99) compared to those who lived in private housing settlements. This could be attributed to housing and social amenity differentials existing between the two housing settlements.

Residents in private sector housing settlements are well served with good modern housing, social amenities such as electricity, water and sewage system opposed to residents in informal settlements. As a result under-five mortality is undoubtedly lower when compared to informal settlements which are characterized by poor housing and in adequate social amenities. It is important also to note that chronic cough and tuberculosis were among the under-five causes of death in the informal settlements which is precipitated by poor environmental and housing conditions such as those found in informal settlements. These findings are consistent to findings of the studies conducted by Peter et al among the Miao in Yunnan, Southwest China in 2001 which demonstrated important links between child mortality and environmental risk factors [45].

Use of candles as a form of energy, in both univariate and multivariate models has shown statistically significant association with under-five mortality in Soweto Townships. The odds of under-five deaths are significantly higher in families where candles are used as form of lighting relative to those families where electricity, solar or gas is the source of energy for lighting (Univariate model; OR 2.67, P-value 0.004, CI 1.372, 5.18 and Multivariate model; OR 7.02, P-value< 0.0001, CI 2.416, 19.15).Use of candles is an indicator of poverty.

The use of paraffin for lighting which did not show any significant association with under-five mortality in univariate model, was however significant in multivariate model. The odds of under-five deaths were 3.4 times more likely in families where paraffin was used as a source of energy for lighting relative to the use of either electricity, gas or solar energies (OR 3.43, P-value 0.014, CI 1.25, 8.88)

Just like candles paraffin is a relatively cheap form of energy and when burnt often emit various pollutants that are harmful particularly to under-five children. Its use undoubtedly has an impact on the health of under-five children as demonstrated by a study undertaken by Wichmann and Voyi on Influence of Cooking and Heating Fuel Use on 1–59 Month Old Mortality in South Africa. The study suggested that exposure to cooking and heating smoke from polluting fuels is significantly associated with 1–59 month mortality (RR=1.95; 95% CI=1.04, 3.68).

Other household characteristics such as source of water, type of toilet facilities, number of household rooms and building materials did not show any significant association with the under-five mortality in Soweto Townships.

4.4 LIMITATIONS OF THE STUDY

The main limitation of the study is the design of the survey itself. A cross-sectional study cannot answer the important question of the causal relationship between the variables (exposure and outcome) because both information on the explanatory and outcome are obtained at the same time.

The mortality figures reported seem to be way below other figures for South Africa, which suggest strong under reporting due to recall bias. Most of the causes of under-five deaths have been reported as others hence limiting the conclusions regarding leading causes of child deaths in the different housing settlements. In addition causes of death as well gender were missing for some of the children who died.

The analysis was restricted to variables in the dataset hence it was not possible to analyse other important variables known to have significant association with child mortality such as sex, mother's education level etc.

Important demographic factors such as sex were missing, hence it was difficult for the researcher to determine the effects of sex on under-five mortality as well as understand the distribution of under-five deaths by sex in the various housing settlements. Other

variables known to have association with under-five mortality such as socio-economic status and household size were as well missing.

It was difficult to ascertain whether the housing settlements in which under-five deaths reported are actually the settlements where the death occurred since information on change of housing settlement within the last five year period was not provided. Information regarding the date of death of the child's mother was not provided and therefore it was difficult to ascertain who died first.

This report is based on secondary data, thus some of the relevant variables to answer some of the important questions were not collected such as mother's educational levels mother's marital status, number of persons housed in a household etc.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This study has examined the differentials existing in under-five mortality rates in different housing settlements in Soweto Townships during a five year period 1998 - 2002. The results have shown that overall under-five mortality rates in private sector housing settlements were lower compared to under-five mortality rates in informal, hostels and backyard housing settlements. No differences exist in under-five mortality rates in private sector and council housing settlements in Soweto Townships.

The study further revealed that housing settlement and source of energy are the main factors associated with under-five mortality in Soweto Townships after adjusting for other household characteristics such as sources of water for drinking, type of toilet facility and number of house rooms. Under-five children living in hostels, council and informal settlements are more vulnerable to death compared to under-five children living in private sector housing settlement in Soweto Townships.

The use of candles and paraffin for lighting increase the risk of death among under-five children compared to the use of electricity, Gas and solar energy sources in Soweto Townships. Household characteristics such as toilet type, Number of rooms and Type of building materials did not show any association with under-five mortality in Soweto Townships.

5.2 RECOMMENDATIONS

The study has revealed an important link between under-five mortality and housing settlement. There is need for the quality of housing in Soweto Townships to be improved to the standards of those found in private sector settlements which have showed lower under-five mortality compared to the other settlements.

Modern energy sources and technologies such as electricity and solar systems have proved to play a vital role in under-five mortality risk reduction as demonstrated in Sri Lanka which has been extraordinarily successful in reducing its under-five mortality rates in the last half the century that currently stand at 13 per 1000 live births. Studies conducted in this country showed that those households having no access to electricity, under-five mortality were 2 times higher than households having access to electricity. It is therefore important that homes without electricity be provided with electricity to avoid the use of candles and paraffin for lighting which have been associated with under-five mortality in Soweto Townships.

More importantly, is to address poverty which seems to be the root cause of development of deprived settlements all over the world and may be explaining the social economic and housing type prevailing in Soweto Townships. Indeed, there is also need to explore hidden environmental and social factors which might also be contributing to the increased risk of under-five mortality in Soweto Townships.

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APPENDICES
APPENDIX ONE: UNIVARIATE MODEL OUTPUTS

(i)Univariate model of under-five mortality and housing settlements

```
xi:logistic Mort_1 i.newdomain
i.newdomain       _Inewdomain_1-5     (naturally coded; _Inewdomain_1 omitted)

Logistic regression                     Number of obs   =       2825
                                        LR chi2(4)      =      11.58
                                        Prob > chi2     =     0.0208
Log likelihood = -372.24676             Pseudo R2       =     0.0153

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_Inewdomai~2 |   3.104409   1.736146     2.03   0.043     1.037393    9.28998
_Inewdomai~3 |   3.634106   2.003479     2.34   0.019     1.233477    10.70691
_Inewdomai~4 |    4.41523   2.425604     2.70   0.007     1.504274    12.95924
_Inewdomai~5 |    4.19913    2.29792     2.62   0.009     1.436647     12.2735
------------------------------------------------------------------------------
```

(ii)Univariate model of under-five mortality and source of Energy

```
xi:logistic Mort_1 i.Energy_source
i.Energy_source   _IEnergy_so_1-4     (naturally coded; _IEnergy_so_1 omitted)

Logistic regression                     Number of obs   =       2814
                                        LR chi2(2)      =       9.07
                                        Prob > chi2     =     0.0107
Log likelihood = -369.67884             Pseudo R2       =     0.0121

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_IEnergy_s~3 |   1.779288   .5407665     1.90   0.058     .9807234    3.228092
_IEnergy_s~4 |   2.665774   .9032352     2.89   0.004     1.372188    5.178847
------------------------------------------------------------------------------
```

(iii)Univariate model of under-five mortality and type of wall building material

```
xi:logistic Mort_1 i.Build_materials
i.Build_mater~s   _IBuild_mat_1-5     (naturally coded; _IBuild_mat_1 omitted)

Logistic regression                     Number of obs   =       2821
                                        LR chi2(2)      =       0.22
                                        Prob > chi2     =     0.8958
Log likelihood = -377.80523             Pseudo R2       =     0.0003

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_IBuild_ma~4 |   1.205357   1.237533     0.18   0.856     .1611359    9.016526
_IBuild_ma~5 |   1.112637   .2648084     0.45   0.654     .6978582    1.773945
```

(iv) Univariate model of under-five mortality and water sources

```
xi:logistic Mort i.water_source
i.water_source    _Iwater_sou_1-3     (naturally coded; _Iwater_sou_1 omitted)

Logistic regression                     Number of obs   =       2807
                                        LR chi2(2)      =       1.60
                                        Prob > chi2     =     0.4498
Log likelihood = -373.20727             Pseudo R2       =     0.0021

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_Iwater_so~2 |   1.140214   .2826373     0.53   0.597     .7014391    1.853459
_Iwater_so~3 |   1.489999   .4597948     1.29   0.196     .8137964    2.728073
------------------------------------------------------------------------------
```

(v)Univariate model of under-five mortality and Number of household rooms.

```
xi:logistic Mort_1 i.Rooms_nos
i.Rooms_nos       _IRooms_nos_1-47    (naturally coded; _IRooms_nos_1 omitted)

note: _IRooms_nos_4 != 0 predicts failure perfectly
      _IRooms_nos_4 dropped and 16 obs not used

note: _IRooms_nos_47 dropped due to collinearity

Logistic regression                             Number of obs   =       2808
                                                LR chi2(2)      =       4.54
                                                Prob > chi2     =     0.1035
Log likelihood = -375.25313                     Pseudo R2       =     0.0060

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_IRooms_no~2 |   .7199014   .1642441    -1.44   0.150     .4603339    1.125831
_IRooms_no~3 |    .359434   .2179684    -1.69   0.092     .1095046    1.179793
------------------------------------------------------------------------------
```

(v) Univariate model of under-five mortality and type of toilet facility.

```
. xi:logistic Mort_1 i.toilet_type
i.toilet_type     _Itoilet_ty_1-3     (naturally coded; _Itoilet_ty_1 omitted)

Logistic regression                             Number of obs   =       2778
                                                LR chi2(2)      =       0.39
                                                Prob > chi2     =     0.8243
Log likelihood = -365.95225                     Pseudo R2       =     0.0005

------------------------------------------------------------------------------
     Mort_1 | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
_Itoilet_t~2 |   1.052819   .3350712     0.16   0.872     .5642211    1.964527
_Itoilet_t~3 |   1.612651   1.184139     0.65   0.515     .3824013    6.800823
------------------------------------------------------------------------------
```

APPENDIX TWO: MULTIVARIATE MODEL STATA OUTPUT

```
xi:logistic Mort_1 i.newdomain i.Energy_source i.Build_materials i.water_source
i.Rooms_nos i.toilet_type
i.newdomain       _Inewdomain_1-5     (naturally coded; _Inewdomain_1 omitted)
i.Energy_source   _IEnergy_so_1-4     (naturally coded; _IEnergy_so_1 omitted)
i.Build_mater~s   _IBuild_mat_1-5     (naturally coded; _IBuild_mat_1 omitted)
i.water_source    _Iwater_sou_1-3     (naturally coded; _Iwater_sou_1 omitted)
i.Rooms_nos       _IRooms_nos_1-47    (naturally coded; _IRooms_nos_1 omitted)
i.toilet_type     _Itoilet_ty_1-3     (naturally coded; _Itoilet_ty_1 omitted)

note: _IRooms_nos_4 != 0 predicts failure perfectly
      _IRooms_nos_4 dropped and 16 obs not used

note: _IRooms_nos_47 dropped due to collinearity

Logistic regression                     Number of obs   =       2734
                                        LR chi2(14)     =      27.05
                                        Prob > chi2     =     0.0190
Log likelihood = -347.81434             Pseudo R2       =     0.0374

------------------------------------------------------------------------------
     Mort_1 |       Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------------------------------------------------------------------------
_Inewdomai~2 |   3.365174   1.890126    2.13   0.032    1.098501    10.12381
_Inewdomai~3 |   2.519372   1.648045    1.29   0.176    0.6610907   9.506119
_Inewdomai~4 |   5.10362    2.675241    2.53   0.005    1.6025824   15.89455
_Inewdomai~5 |   4.092971   2.131604    2.33   0.020    1.242855    11.42454
_IEnergy_s~3 |   3.42689    1.66107     2.40   0.014    1.248159    8.865632
_IEnergy_s~4 |   7.021591   3.566894    3.62   0.000    2.406577    19.01456
_IBuild_ma~4 |   0.7552301  0.7976152  -0.27   0.790    0.095303    5.984833
_IBuild_ma~5 |   0.5962384  0.2172533  -1.42   0.156    0.2919207   1.217797
_Iwater_so~2 |   0.7776655  0.2303333  -0.85   0.396    0.4351903   1.389653
_Iwater_so~3 |   0.602572   0.3166111  -0.96   0.335    0.2151591   1.687556
_IRooms_no~2 |  0.8292717  0.2332674  -0.67   0.506    0.4778161   1.439239
_IRooms_no~3 |  0.4712081  0.3078451  -1.15   0.249    0.1309526   1.695553
_Itoilet_t~2 |    0.747281  0.3320463  -0.66   0.512    0.3127963   1.78528
_Itoilet_t~3 |   1.193837   0.9807063   0.22   0.829    0.2386189   5.972899
------------------------------------------------------------------------------
```