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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

RESEARCH REPORT

PROJECT TITLE:

THE EFFECT OF DISTANCE TO FORMAL HEALTH FACILITY ON CHILDHOOD MORTALITY: CASE OF IFAKARA DSS IN RURAL TANZANIA.

A research report submitted to the school of Public Health, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Medicine for the year 2008.

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Declaration

I, Daniel Kadobera declare that this research report is my own work. It's being submitted for the Master of Science in Medicine degree in the field of Population Based Field Epidemiology in the University of Witwatersrand. It has not been submitted before for any degree or examination at this or any other University.

Signature: …….

Full Name: KADOBERA DANIEL

Date: ……

Dedication

Dedicated to my family, especially my Dad, Mum and Wife for the unlimited support and encouragement during my stay at Wits.

Acknowledgement

I am indebted to the INDEPTH-NETWORK for the scholarship award through its Scientific Development and Leadership Programme without which undertaking this MSc would have been impossible. My supervisors Benn, Mathew and Honorati - Thank you very much.

I would like to acknowledge the support received from Makerere University, School of Public Health, Makerere University School of Graduate Studies and Iganga/Mayuge Health & Demographic Surveillance Site without which, acquisition of INDEPTH sponsorship and admission into the program would not have been possible.

My sincere thanks go to the Ifakara Health Institute for giving permission to use the Ifakara Health & Demographic Surveillance Site data which served as a basis for this research report. Dr. Rose Nathan, thank you very much for you encouragement and support during my stay in Ifakara.

Lastly, I would also like to thank my colleagues and staff of Wits School of Public Health for the knowledge I have acquired during my stay at Wits.

Abstract

THE EFFECT OF DISTANCE TO FORMAL HEALTH FACILITY ON CHILDHOOD MORTALITY: CASE OF IFAKARA HDSS IN RURAL TANZANIA.

Kadobera D.[1 3], Sartorius B.[3], Masanja H.[2], Alexander M.[2]

Background:

MDG 4 commits the international community to reducing mortality in children younger than 5 years by two-thirds by 2015.The biggest burden of child mortality lies in Saharan Africa.

Objective:

To investigate how distance from home to the nearest health facility is associated with infant and child (1-4 years) mortality in a typical rural setting of sub Saharan Africa.

Methods:

A secondary analysis of 28,823 under five children in Ifakara Health and Demographic surveillance system between 2005 and 2007 was carried out. Both Euclidean and networked distance from the household to the nearest health facility was estimated using geographical information system methods. Cox proportional hazard regression models were used to investigate the effect of distance from home to the nearest health facility on infant and child mortality.

Results:

Children who lived in homes with networked distance >5KM experienced about 18% increased mortality risk [HR=1.18;95%CI 1.02-1.38 p-value 0.05] compared to those who lived less than 5KM networked distance to the nearest health facility. Death of mother, death of preceding sibling and multiple births were the strongest independent predictors of child mortality. Malaria/AFI and pneumonia/ARI were the leading causes of death in children although there was no evidence to show association of cause specific mortality with networked distance in the study.

Conclusions:
Staying closer to the health facility improved the survival probability of the children. This effect was similar to that reported elsewhere in other studies which re-emphasize the usefulness of having fully functional health facilities closer to the populations that need them. The inconsistency of the Euclidean distance in the study further suggests that the networked distance is a better estimator of geographical accessibility and should be the preferred proxy distance measurement option in public health research.

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Definition of terms

Under-five mortality rate (U5MR): Probability of dying before 5^{th} birthday expressed as a rate per 1,000 person years of observation.

Crude death rate: Total number of deaths per 1,000 people in a given year.

Crude birth rate: Number of live births per 1,000 people in a given year.

Health facility: A public or private owned Institution which provides medical or health-related services.

Infant mortality rate (**$_1q_0$**): The probability of dying before the first birthday expressed per 1000 person years of observation.

Child mortality rate ($_4q_1$**):** The probability of dying between one and four years expressed per 1000 person years of observation

Under-five mortality rate ($_5q_0$**):** The probability of dying between birth and fifth birthday expressed per 1000 person years of observation.

Euclidean Distance: The straight line distance between two points (e.g Household and health facility)

Networked Distance: Is the distance involved in traversing a network of roads or paths i.e Path between two points as if taken on foot or vehicle.

List of acronyms and abbreviations

IHDSS – Ifakara Health Demographic Surveillance System

GPS – Global Positioning System

DSS – Health and Demographic Surveillance System.

DSA – Demographic Surveillance Area.

MDG - Millennium Development Goal

SES – Social Economic Status

IMR – Infant Mortality Rate

CMR – Child Mortality Rate

U5MR – Under five mortality rate

HF – Health Facility

KM – Kilometres

DHS – Demographic and Health Survey

HRS – Household Registration System

HIV - Human Immunodeficiency Virus

AIDS - Acquired Immunodeficiency Syndrome

PCA – Principle Component Analysis

UNICEF - United Nations Children's Fund

WHO - World Health Organization

INDEPTH - International Network for Continuous Demographic Evaluation of Populations and Their impact on Health in Developing Countries

SSA – Sub Saharan Africa

PYO – Person Years of Observation.

ICD 10 – International Classification of Diseases' 10^{th} Version

GIS – Geographical Information System

CHAPTER ONE: INTRODUCTION

1.1 Background

The fourth Millennium Development Goal (MDG 4) commits the international community to reducing mortality in children aged younger than 5 years by two-thirds between 1990 and 2015 (Lawn et al. 2005). Worldwide, about 10 million children die every year, among these about 90% occur in the less developed countries. In sub Sahara Africa, it's estimated that 42% of children die before they are five years (Unicef, 2007), and some of the countries in SSA have shown increasing, stagnant or declining under 5 mortality with children living in rural areas and in the poorest households registering higher child mortality (Unicef, 2007). Under 5 mortality rate is an indicator of the level of child health and overall development in countries. Globally, under 5 mortality is expected to reduce by only 27% if the current reduction rates are maintained, this is far below the required 67%. It has been argued that the slow reductions in sub Saharan Africa are greatly hindering global progress on MDG 4 (Jones et al. 2003;Murray et al. 2007).

A major breakthrough in child health of halving the risk of dying in the first 5 years of life happened between 1960 and 1990 but achieving the 4th MDG will heavily depend on reducing the under 5 mortality by even greater percentages (Lawn et al. 2005). In recent times there has been stagnation and reversal in the previous gains made in child mortality in countries from the sub Saharan region due to HIV/AIDS and related diseases (Agbessi & Kenneth 2004;Tollman et al. 1999).

The major causes of the child mortality burden globally are understood to be more related to poor perinatal conditions and infectious diseases (Jones et al. 2003). Current assessment of child mortality in low-income countries indicates that much of it is preventable if effective

coverage of available cost-effective interventions can be achieved (Masanja et al. 2008). A recent analysis of Tanzania DHS datasets reported a drop of 24% in child mortality between 2000 and 2004 (Masanja et al. 2008), thus placing Tanzania amongst the very few African countries that are on course of achieving MDG 4 target on child mortality if the current trend is sustained.

Risk factors for child mortality in low income countries like Tanzania range from social economic status, fertility behaviour, environmental health conditions, nutritional status and infant feeding to use of health services (Hammer et al. 2006). It has been noted that in Tanzania, inequalities in health accessibility and affordability of health services are among the obstacles for quality health in the population (NBS, 2005).

In developing countries like Tanzania, estimates of under five mortality are based on census and surveys in the absence of vital registration. In recent years, Health and Demographic Surveillance Systems (HDSS) have been set up in various sites in Africa and Asia. In the absence of effective vital registration and information on mortality, these health and demographic surveillances systems have well developed structures and standard operating procedures established to periodically monitor vital events like births, deaths and migrations in a well defined unit of the population to produce population health information (Chandramohan et al. 2008).The DSS's provide a useful, timely and reliable source of information on population based health information to support evidence based health policies.

This study was carried out in Ifakara, a rural area in Tanzania characterized by food insecurity, poverty (Tanya et al. 2004) and weak health systems and it primarily assessed the effect of distance from home to the nearest health facility as a risk factor for child mortality

using the Ifakara Health and Demographic Surveillance system (IHDSS) databases. The study used Geographical Information Systems (GIS) methods which allowed sophisticated and often underutilized spatial analysis potential on DSS data. As demonstrated by (Brabyn & Skelly 2002), GIS can be used to assess accessibility more accurately over large networks using thousands of demand points.

1.2 Problem Statement

The 4th Millennium Development Goal (MDG 4) is to reduce child mortality by two thirds by 2015, but a number of key risk factors for child mortality like effect of geographical accessibility of health facilities by the population have not been assessed in adequate detail. To reach the MDG-4 target, massive improvements are required in coverage of essential interventions as it has been demonstrated that most child deaths could be prevented with available and simple low cost interventions that are currently not reaching the poor children (Bryce & Cesar 2005). With preventive and curative medicines available for the major causes of child mortality, the bulk of the rural population in developing countries are still unable to get interventions in time to save children's lives. This situation is brought about by a combination of factors like long distances to the nearest health facility. The effect of access to health facilities is even higher during childhood years because infectious diseases common in this age group can easily be controlled, hence access factors are very important (Katende, 1994).

In most low income countries like Tanzania, low level facilities are an important pipeline for delivering interventions to the general population. Unfortunately in many of these settings the nearest health facility may take hours or days to reach and the distance to the health facility can be compounded by lack of funds for transport, insufficient transportation, poor road

network or the rainy season which makes some areas unreachable. Under these circumstances diseased children who fail to get interventions in time may die or suffer from disability because the nearest health facility is actually not near to save life.

1.3 Justification of study

Because disease is inevitable, sick children do not have to die especially if interventions are available. Currently interventions for the main causes of under 5 mortality are readily available at the lowest health centre level but these conditions still pose the heaviest mortality burden in the population. Issues of 'access' which includes accessibility, affordability and acceptability of available health services heavily contribute to the current child mortality burden (Penchansky & Thomas 1981).

Eight out of every ten children die at home with six of them dying without any contact with health facilities in Tanzania (Tanzania Ministry of Health 2003). This could be due to the large disparities between the poor-rich, income inequalities or geographical accessibility of health facilities among other factors.

There is still need for more research to provide a clear understanding of the role of distance to nearest health facility as a hindrance to accessing health services in low income settings of Tanzania. This will provide sufficient knowledge for the design and implementation of equitable health systems policies for populations with poor geographical access to health facilities or policies to extend/expand health services delivery to the population with an aim of improving accessibility. This will go a long way towards reducing the number of neonatal, infant and child deaths from preventable and curable diseases and in the improvement of quality of health in the population.

1.4 Literature review

1.4.1 Child Mortality

Pneumonia, diarrhoea and neonatal disorders continue to be the biggest causes of child deaths in the world although malaria and AIDS play an important part in child mortality in many countries in sub-Saharan Africa (Black et al. 2003). Reduction of current child mortality burden by two- thirds can be achieved by 2015 in low income countries with interventions available today but the main challenge is to transfer what we already know into action and deliver the interventions to the children, mothers, and families who need them (Jones et al. 2003;Masanja et al. 2008). High coverage levels of an intervention like measles vaccination provides a good example of an effective intervention that has heavily contributed towards reducing the current child mortality burden (Jones et al. 2003).

Remarkably, there has been an observed drop in child mortality rates in the past few decades in sub Saharan countries due to improved access to new and efficient heath services, health education, vaccination and malaria programs initiated in the 1960s and 1970s (Pison et al. 1992;Valerie et al. 2001) but since the 1990's, child mortality rates have increased in many parts of sub Saharan countries and this could be attributed to effects of the HIV/AIDS epidemic and the emergence of chloroquine-resistant malaria (Becher et al. 2004).

The Tanzania demographic and health reports that one in every nine children born in Tanzania die before their fifth birthday showing an overall gradual drop in child mortality in the last 10 years (NBS & ORC Macro. 2005), with 28% of under five deaths occurring in neonates, 40% during the post neonate period and 36% between the age 1-4 years (NBS & Macro International Inc. 2000)

1.4.2 Maternal risks factors

The social demographic factors of the mother and child have been shown to affect child mortality directly. Factors like Maternal age, education, child parity, short birth intervals and previous child deaths have been shown to exert influence on Infant and child mortality outcomes with increased risk to death especially amongst rural women in less developed countries (Becher et al. 2004;Hammer et al. 2006;Mosley & Chen 1984;Mturi & Curtis 1995;NBS & Macro International Inc. 2000).

Mothers are a heavily vulnerable group in these societies despite them being the sole caregivers to the infants. More than a decade ago the Tanzania government reinstated programmes encouraging women to space their births at least two years apart and delay childbearing beyond the teenage years in an effort to reduce infant and child mortality in the population (Mturi & Curtis 1995).

1.4.3 Social Economic Status

Using an index of asset ownership for categorizing households into socioeconomic groups, studies have shown that the households in the poorest category had worse health status indicators compared with those in the least poor category (Houweling et al. 2005;Mahmud Khan et al. 2006).

Social economic status has been reported to be a risk factor for child mortality especially in rural or low income setting (Debpuur et al. 2005;Kahn et al. 2005). Similarly in Tanzania (Nathan et al. 2005) observed that child mortality rates were fairly stable in the first three social economic classes but were followed by a sharp drop in the less poor social economic classes in rural Tanzania.

Health outcomes in many homesteads are not only determined by the household's social economic status or income but factors like choice and timing of use of curative or preventive services (Katende 1994), urbanisation and illiteracy of mainly women has been reported to affect child mortality (Agbessi & Kenneth 2004). It's also known that social economic status is more associated to child (1-4) deaths than infant and neonatal death because deaths after birth are more associated to biological factors like birth order, maternal age than social economic status of the household (James, 1987).

1.4.4 Access to health facility

Access to health care can be defined and interpreted in many ways because of its ambiguity and multiple interactions with a number of factors. (Penchansky & Thomas 1981) provide one of the useful definitions that describe access to health care as a combination of accessibility, availability, affordability, acceptability and accommodation. Access in terms of distance or travel time to the nearest health facility affects heath care seeking and utilisation of available interventions in low income settings. Primary health care usage patterns decline with increasing distance or travel time to the facility showing that distance to the health facility is an important factor in determining the utilisation of health facilities in rural areas in less developed countries (Muller et al. 1998;Tanser et al. 2006;Thaddeus & Maine 1994).

Health care facilities are a key player in the delivery of effective and timely interventions to the populations but they often experience insufficient staff and drugs stocks. This spells extra disaster for health seekers because it's not only proximity to health facilities that is required but also proximity to quality basic health services (Smithson, 2006). The interaction of access in terms of distance or travel time to health care and insufficient staff and drug stocks can be a significant determinant of health outcomes in the population.

Few studies have documented the relationship between distance or travel time and health outcomes. (Kasumpa 2005) and (Becher et al. 2004) in studies in Zambia and Burkina Faso respectively provided evidence that increasing travel time or distance to health facility was associated with increased child mortality risk. Similarly, in Uganda it was reported that access to health facility affects childhood mortality and the effect was more evident to children born to un educated mothers (Katende 1994).

In Tanzania, its documented that infant and child mortality in families that lived over 5KM from the nearest health facility increased thus clearly showing that even peripheral health facilities still have a huge potential of improving the health and survival of families with the current available interventions and resources if distance or travel time could be reduced (Schellenberg et al. 2008). On the other hand transport in rural Tanzania is scarce, be it public or private and often patients have to walk long distances to the nearest health facility sometimes in difficult terrain to get health care(Masuma & Bangser 2009).

Geographical Information Systems (GIS), euclidean distance models and other sophisticated models that take into account the proportion of people likely to be using public transport, knowledge of road networks, natural barriers, topography and land usage have been developed to accurately estimate the impact of distance (Noor et al. 2006;Tanser et al. 2006).

Introducing more health posts as close to the people as possible has been recommended by previous studies after determining that in a number of cases, distance and time taken to reach health facilities tends to discourage care seekers to seek health care resulting in death of the child (Kasumpa 2005).

Despite the strong evidence available showing the relationship between distance to health facility and child mortality, some studies have reported the contrary showing that greater distance to the health care centre is not necessarily associated with increased risk of child mortality (Dummer & Parker 2004;Goodman et al. 1997).

This study, therefore investigated the effect of distance from home to the nearest health facility on child mortality while adjusting for confounding factors such as mother status, mother education, mother's age and social economic status of the household in an effort to clearly apportion the contribution of distance to health care on the current burden of child mortality in rural Tanzania.

1.5 General objective

The main objective of this study is to investigate how distance from home to the nearest health facility is associated with infant and child (1-4 years) mortality in two districts of rural Tanzania between 2005 and 2007.

1.5.1 Specific objectives

1) To estimate the all cause and cause specific infant and child (1-4 years) mortality rates in the Ifakara DSS area between 2005 and 2007.

2) To construct measures of distance to health facility in Ifakara DSS area.

3) To quantify the impact (risk) of distance from home to the nearest formal health facility on all cause and cause specific infant and child (1-4 years) mortality adjusting for various confounding factors.

2 CHAPTER TWO: METHODOLOGY.

2.1 Study area.

The Ifakara HDSS is about 320 km from Tanzania's administrative city of Dar es Salaam in the south western region of Morogoro and includes 25 villages of Kilombero and Ulanga districts (Appendix 1). The area covers 80KM X 18KM in Kilombero district and 4KM x25KM in Ulanga district thus making a combined total area of 2400 KM^2.The two districts are separated by the Kilombero river and the Udzungwa mountains lie to the northwest. The annual rainfall ranges between 1200-1800mm with an annual mean temperature of 26^oC (Schellenberg et al. 2002).

2.2 Study Population characteristics.

The DSA has a population of 84 000 people living in 19,000 scattered rural households with a population density of 35 people/km^2. The population is ethnically heterogeneous with each ethnic group speaking their own language although the national language Swahili is also widely spoken. Majority of the population practice Christianity (60%) or Islam (40%) (Schellenberg et al. 2002).

The population is predominantly rural practising subsistence farming and fishing as the main occupations with Rice and Maize the predominant food crops. Most families live in Mud walls and thatched roof houses but they also have a second house known as ***shamba*** house (farmhouse), where they stay during the planting and harvesting seasons. The population is highly mobile with most families moving between the main home and the ***shamba*** home depending on the season at the time. Shallow wells, open wells and rivers are the common sources of water in the area and majority of the homes do not have electricity. Infectious diseases are the main causes of mortality and morbidity with malaria causing the biggest burden (Schellenberg et al. 2002).

The population structure in 2007 was 3% <1 year, 16% between 0–4 years, 26% are 5–14 years, 53% between 15–64 years and 4% are 65 years and above. The average household size in this population is 5 persons with an age-dependency ratio of 87% and sex ratio of 97 males for every 100 females.

The crude death rate (CDR) and crude birth rate (CBR) were 10.1 and 35.1 respectively for every 1000 person years of observation in the DSA in 2007. The infant mortality rate ($_1q_0$) is 65 per 1000 live births, and mortality in children 1–4 years is 99 per 1000 per year. In 2007, the TFR was estimated at 4.8 births per women.

The public health system in the DSA consists of village health workers, dispensaries, health centres, and hospitals. There are a total of 13 dispensaries and 2 health centres in the DSA providing preventive and curative services to the population. Additionally, there are two district hospitals outside the DSA. The immunisation rates are above 80% and malaria is the leading cause of admission and OPD for both children and adults in the area.

2.3 Inclusion criteria

Included all children less than 5 years between January, 2005 and December, 2007 and resident in the Ifakara Health Demographic Surveillance Area (IHDSS). Children were censored at 31 December 2007 if still alive and less than 5, at age 5 if this occurred within the study period, or if they out migrated within this period before age 5.

2.4 Exclusion criteria

All persons who were 5 years and above on 1 January 2005 and resident in the Ifakara Health Demographic Surveillance Area will be excluded from the study.

2.5 Study design

This was a retrospective population-based cohort study using a longitudinal dataset collected by the IHDSS. Secondary data analysis was carried out on the data collected on under 5 children residing in the DSA. An initial census was conducted at the start of the DSS to collect demographic data of the whole population and consequent surveillance of mortality in the delineated DSS area. After the initial census conducted in late 1996, the database has been continually updated since January 1997, but this study will use data for a 3 year period (2005-2007).

2.6 Sample selection

The study included all eligible under 5 children between 2005 and 2007 living in households with geo references.

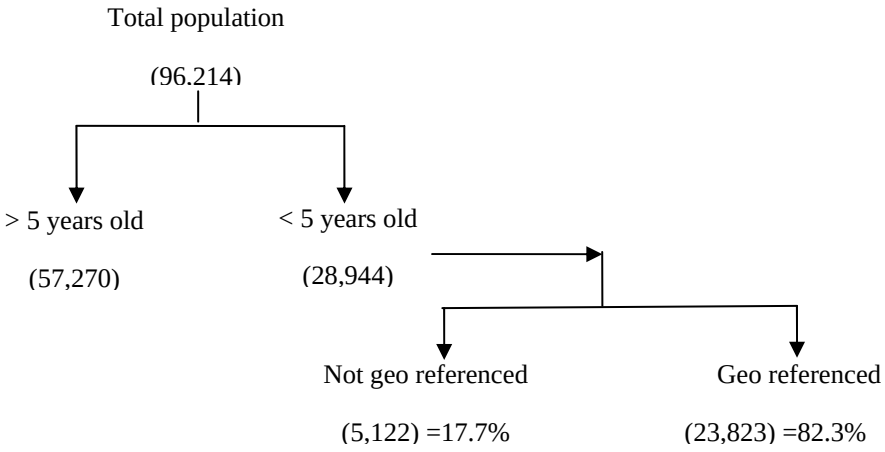


Figure 2.1: Sample selection schematic

2.7 Measurement and data sources

The Ifakara Health and Demographic Surveillance System (IHDSS) monitors key demographic events and socio-economic variables in the Kilombero and Ulanga districts, an area lacking vital registration. The IHDSS was formed with an original aim of providing a framework to evaluate social marketing for treated mosquito nets. The IHDSS conducted an

initial baseline census of all the people in the delineated areas of Ulanga and Kilombero districts from September to December 1996. The variables recorded were people's names, sex, date of birth, and relationships within the household. A standard baseline questionnaire was used in the collection of all the above variables and the initial population for the area was 53000 which has subsequently grown to 96000 by the end of 2008.

The variables measured routinely by the IHDSS include: births, deaths, in and out migration, household relationships, residency status and pregnancy. Annually the education and social economic status of the population is assessed. Subsequently every new person (birth or in-migration) in the DSA after the baseline census has his/her demographics and place of residence information recorded to update the baseline database.

During the census update round, a trained field worker interviewed an adult or the most knowledgeable respondent aged eighteen or above available at the time of the household visit. All individual information recorded at the last visit is checked for every household member and all the events that occurred since the previous update round are captured. Since January 1997 every household has been visited every 4 months by a DSS interviewer and changes in both household and individual records have been recorded in the Household Registration System (HRS) data management software.

All recoded deaths are collected using death questionnaires during the update round and are then followed up by a bereavement interview (Verbal Autopsy) administered to the person most closely involved with the deceased in the last days of illness. The VA questionnaire is designed to collect responses about the date and place of death, symptoms, signs and history of events prior to the deceased's death. Two physicians are then assigned the VA questionnaires for an independent review and assign a probable cause of death of the deceased using the ICD 10 coding system. In case of discordant outcome from the first two

physicians, a third physician independently reviews the VA. The cause remains undetermined in case of a third discordant outcome.

Geo referencing of all households, health facilities, sources of water, schools and roads system in the DSA was done in 2006. All households that dissolved prior to the geo referencing exercise were not assigned coordinates. The GPS coordinates have since been used to determine household locations, boundaries of areas of interest and in the developing of maps for the DSS.

Field supervision and quality control of the data is vigorously carried out in Ifakara HDSS. Every week, supervisors revisit a randomly selected 10% of the households visited by DSS interviewers and repeat the interview. Supervisors also carry out accompanied interviews with a convenience sample of two households for every interviewer per week. The assistant field managers also carry out spot checks on every interviewer and supervisor at least once each round.

To check for the reliability of the data collection tools, a pilot study of every data collection tool has to be carried out before the tool is unveiled for routine data collection in the DSS.

2.8 Data management and processing

The IHDSS data entry and management is done in the Household Registration System (HRS II) which runs in FOXPRO (Microsoft Corp., Seattle, USA) database environment. The tables are in DBF format and the data base is composed of a number of different tables that are related to each other by unique identifiers.

All data management and processing for this research was done in STATA 10 Statistical package. The DBF tables from FOXPRO were extracted and converted to STATA with the help of DBMSCOPY 7 software. Missing values, inconsistent and incomplete data were all

identified and corrected in STATA during the cleaning stage. All the variables for this research were extracted from the following tables:

Membership: Contains records of every individual who has ever resided in the DSA for 120 consecutive days. The records are uniquely identified by an individual's permanent ID. Individual variables like names, date of birth, gender, entry and exit date are found in this table.

Family: Contains records of each family/households found in the DSA. It contains records like family ID, household head's name, date of last visit, village, etc.

Pregnancy Outcome: Stores attributes recorded about a pregnancy outcome. Attributes include Mother ID, date and type of outcome, place of birth, etc

Social Economic Status: Contains information about household characteristics and assets that are updated annually and are useful in the estimation of the household asset index. The attributes here include roof type, source of power; firewood, kerosene/biogas or electricity, ownership of a bicycle, radio, car, motorbike, mobile phone and livestock.

Education: Stores information pertaining the number of completed years of education completed by individuals in the DSA.

All these tables were linked to each other by either the individual permanent ID or the household ID and through these unique identifiers, all the required variables were extracted and stored into one table. The coding and editing was done on the extracted variables in STATA.

2.8.1 GIS methods

GIS methods were used to analyze the main exposure variable which was distance. Networked road distance and Euclidean (straight line) distance from home to nearest health facility were the 2 types of distance that were analyzed in this study. The IHDSS had all households, roads and small paths, health facilities and schools in the DSA geo referenced in 2006. Mapped households and health facilities using the global positioning system (GPS) enabled spatial distributions and analyses of distances between household and health facilities that greatly minimized errors attributed to subjective reporting of distances or travel time by the respondents.

With the help of ArcView 9.1 software, 3 shape files were generated i.e. roads/small paths shape file, household shape file and health facility shape file (See appendix 1). Using the network analyst tool in ArcView, a routes feature layer was generated after the analysis, which stored the resultant shortest networked and Euclidean routes from households to the closest health facility. Computation of the networked distance is more complex because it necessitates path and road network files that had to be generated and could include directions, speed limits, barriers, type of road surface to produce a more accurate measurement. Road surface, barriers and speed limits could not be collected in this study and are therefore missing in the computation of the networked distance variable.

2.9 Study variables

2.9.1 Outcome variable

All Child deaths that occurred between January, 2005 and December, 2007 in Ifakara DSA and these were captured by field interviewers during follow up visit to the households carried out after every 4 months. This was coded as a binary with all children who experienced a death being coded as 1 and those who survived or out migrated as 0. Cause specific outcomes

analyzed in this study were Malaria/AFI, Pneumonia/ARI, Diarrhoea/Malnutrition and HIV/TB.

2.9.2 Exposure variable

Distance from home to the nearest public health facility in the 2 districts of Kilombero and Ulanga. Networked distance along roads and straight line distance to the nearest health facility was measured using GIS methods and categorized as less than 5KM and equal or more than 5KM distances.

2.9.3 Other exposure variables

Child factors

Age at start of study

Sex - Females as 1 and Male were denoted as 2.

Season – This was generated based on the month of birth of the child and categorized into dry or rainy season. Dry season included:-May, June, July, August, September, October, November & December while Rainy season included:-January, February, March & April.

Death of previous sibling – Coded as 1 for all children who previous siblings are alive and 2 for children whose previous siblings died.

Maternal factors

Maternal age groups - Age was generated as the difference between birth date and start of study date (01/01/2005) and categorised in four groups of less than 20, 20-29, 30-39, more than 40 years.

Maternal education – This variable was recorded as either none for women with no education, primary for woman who reported attaining some primary education and post primary for women who reported attaining more than primary education.

Mother death in childhood – This was coded as a binary variable with 0 indicating all children who lost their most before age 5 and 1 for all children whose mothers did not die before age 5.

Fertility factors

Parity – This was recoded into three categories with 1 representing children whose parity is 1, 2 for children whose parity is between 2 and 3 and 3 for those children who parity is 4 and above.

Multiple births – This was coded as 1 for mothers who experienced a single outcome birth and 2 for multiple outcome birth.

Birth spacing to next youngest sibling – This was generated as a difference between birth dates of children following each other in birth order.

Household factors

Family size – This variable was recoded into 2 groups i.e. households with one or two persons and with more than 3 persons in the household.

Wealth index – This was constructed through asset ownership and household characteristics collected during the annual social economic status questionnaire. Variables were then coded as 1 or 0 denoting presence or absence of the assets or characteristics. The principle component analysis (PCA) technique was used to group the households into 5 quintiles (poorest, poorer, poor, less poor and least poor) with the first principle component being a linear index of variables with the largest number of common variables (Filmer & Pretchett 2001;Vyas & Kumaranayake 2006). Only households that had children under 5 years during the observation period were included in construction of the wealth quintiles.

2.10 Data analysis

Frequency distributions

Frequency distributions of infant and child (1-4 years) in the DSS area were constructed by different covariates (district, child age, wealth index, maternal age and education).

High risk area maps

Maps showing potentially higher risk areas for child mortality within the IHDSS area relative to distance to the nearest health facilities were developed using hazard ratio predictions from stata based on the minimum network distance to the nearest health facility as a continuous covariate rather than categorized (<5KM, >=5KM). Risk maps were developed in MapInfo Professional 9.5.

Infant and child mortality

The estimation of infant and child (1-4 years) all cause and cause specific mortality rates in the DSS area for the 3 year study period was done with person years of observation as the denominator. The infant and child (1-4) mortality rates were further broken by Euclidean and networked distance variables.

Kaplan Meier (K-M) survival estimates and graph for overall survival in the DSA was developed. The K-M survival estimates of cumulative probability of survival or death among infants and children (1-4 years) by age, gender, SES quintiles, networked and Euclidean distances to the nearest health facility were further developed expressed per 1000 person years of observation.

Regression

The analytical data analysis involved construction of survival functions for the whole study population, gender, networked and Euclidean distance categories. Cox proportional hazard regression models were constructed to determine the association between distance to the nearest health facility and infant and child mortality. The person time calculations were based on the residency dates of the children included in the study. The survival analysis was the most preferred analysis of the data due to the longitudinal nature of DSS data that provides the opportunity to study time till an event occurs, which is child mortality in this case. Univariate cox regression models of independent variables were fitted against infant, child and under 5 mortality. Only variables that were statistically significant at 10% level were then included in the adjusted multivariate model with networked and Euclidean distance variables. Interaction and confounding factors in the adjusted model were also investigated at this stage. The proportional hazards assumption was also tested for the various models in this study using the stphtest command in STATA that is based on the Schoenfeld residuals.

2.11 Ethical consideration

Ethical clearance and approval for analysis was sought from both the Ifakara Health Institute (IHI) Institutional Review Board (IRB) and Wits Ethics Committee before commencement of the research in January 2009.

Informed consent is duly attained by all field staff from respondents during the update round visits. All participants in the study are identified by unique identifiers and all personal identifiers in the data set were removed before any secondary data analysis took place in order to maintain participant confidentiality.

Access to the data is restricted to only staff and all study tools are securely looked up in a safe room for storage after all the data has been extracted.

2.12 Dissemination and utilization of the results

The findings of the study will be shared with health managers in Tanzania at both the district and national level for improved information based planning strategies for the local communities.

Presentations of this work will be made to the scientific community of Ifakara Heath Institute (IHI), the Indepth-Network and the University of Witwatersrand School Of Public Health.

Findings from this study will be incorporated into the Ifakara DSS community sensitization program as a means of feedback to the community from whom data for the study was collected.

3 CHAPTER THREE: RESULTS

The results of this study are presented in this chapter and they are split into 3 basic areas based on the objectives of the study:

- Description of Socio demographic characteristics of the children in the study and the top ten causes of child death. Estimation of all cause and cause specific mortality incidence by Kaplan-Meier (K-M) survival estimates expressed per 1000 person years of observation. All cause mortality incidence was further estimated by Euclidean and networked distances from homes to nearest health facility.

- Description of Euclidean/straight line and networked distances broken down by infant and child overall as well as mortality rates.

- Description of the relationship (risk) between networked distance from home to the nearest formal health facility and all cause & cause specific child mortality.

The results presented below are of all children who had their homes geo referenced during the subsequent update rounds carried out in IHDSS. About 18% of the households in IHDSS were excluded in the analysis because of missing geo reference codes. The excluded households were compared to the included households in terms of various socio-demographic characteristics to investigate presence of bias.

3.1 Socio demographic characteristics

The socio-demographic characteristics of children in the study are shown in Table 3.1. In the 3 years period (2005-2007), a total of 23823 children under five years living in 13845 households were registered in the IHDSS. Of these a total of 917 child deaths were recorded in both districts; Kilombero 556 (3.9%) and Ulanga 361(3.8%). There were 748(81.6%) infant deaths and 169(18.4%) child (1-4) deaths in the study. Male children had a higher

proportion of deaths (4.2%) as compared to females (3.5%). The mean age and standard deviation of the children at the start of the study was of 1.6 and 1.7 years respectively.

A higher proportion of deaths occurred in children who resided with their mother's (4.8%) as compared to those who not live with their mother's (1.8%). Majority of the mother's ages ranged between 20 to 29 years with a mean age of 27.6 years and SD of 7.5 years. Women younger than 20 years of age had the highest child deaths (7%) compared to those women aged between 20 to 30 years and above 40 years. Children borne of a multiple birth outcome 81 (12.7%) and to women of no formal education 87(4.7) had higher proportions of child deaths. Farming was the predominant occupation of household head which had the highest child deaths 633(3.9%). Mortality was noted to be highest amongst children who reported the death of a previous sibling 39 (14.4 %) compared to those who did not report death of a sibling. The mean birth intervals to next sibling and to previous sibling were 37.1 months and 36.6 respectively.

Table 3.1 Socio-demographic characteristics of the children in the IDHSS between 2005 and 2007

Variable	Dead: n (%)	Alive: n (%)	Total: n (%)
District (n=23 823**)**			
Kilombero	556 (3.9)	13 657 (96.1)	14 213 (100)
Ulanga	361 (3.8)	9 249 (96.2)	9 610 (100)
Gender (n=23 823**)**			
Male	502 (4.2)	11 366 (95.8)	11 955 (100)
Female	415 (3.5)	11 540 (96.5)	11 868 (100)
Age (Mean,SD)	1.6	1.7	23 823
Family size[1] (n=23 823**)**			
1-2	505 (3.5)	14 107 (96.5)	14 612 (100)

3+	412 (4.5)	8 799 (95.5)	9 211 (100)
Season (n=23 823**)**			
Rainy	285 (3.9)	6 971 (96.1)	7 256 (100)
Dry	632 (3.8)	15 935 (96.2)	16 567 (100)
Co-residence of Mother (n=23 823**)**			
Yes	778 (4.8)	15 320 (95.2)	16 098 (100)
No	139 (1.8)	7 586 (98.2)	7 725 (100)
Mothers age[1] (n=16 098**)**			
< 20	180 (7.0)	2 399 (93.0)	2 579 (100)
20 -29	354 (4.6)	7 425 (95.5)	7 779 (100)
30-30	219 (4.6)	4 513 (95.4)	4 732 (100)
40+	25 (2.5)	983 (97.5)	1 008 (100)
Multiple birth[1] (n=16 098**)**			
Multiple	81 (12.7)	555 (87.3)	636 (100)
Single	697 (4.5)	14 765 (95.5)	15 462 (100)
Mother death[1] (n=16 098**)**			
Yes	37 (19.0)	158 (81.0)	195 (100)
No	741 (4.7)	15 162 (95.3)	15 903 (100)
Mothers education[1] (n=12 172**)**			
None	87 (4.7)	1 781 (95.3)	1 868 (100)
Primary	430 (4.3)	9 685 (95.8)	10 115 (100)
Post primary	5 (2.7)	184 (97.4)	189 (100)
Parity[1] (n=11 774**)**			
1	163 (7.9)	1 889 (92.1)	2 052 (100)
2 to 3	245 (5.4)	4 289 (94.6)	4 534 (100)
4+	303 (5.8)	4 885 (94.2)	5 188 (100)
Wealth quintiles[1] (n=23 302**)**			
Poorest	158 (4.2)	3 572 (95.8)	3 730 (100)
Poorer	164 (3.7)	4 333 (96.4)	4 497 (100)
Poor	203 (3.8)	5 165 (96.2)	5 368 (100)
Less poor	183 (3.9)	4 495 (96.1)	4 678 (100)

Least poor	186 (3.7)	4 843 (96.3)	5 029 (100)
HHH* Occupation[1] (n=23 154**)**			
Farming	633 (3.9)	15 587 (96.1)	16 220 (100)
Causal worker	36 (3.4)	1 036 (96.6)	1 072 (100)
Business	107 (3.8)	2 712 (96.2)	2 819 (100)
Gov't employee	80 (4.1)	1 859 (95.9)	1 939 (100)
Other	34 (3.1)	1 070 (96.9)	1 104 (100)
Death of previous sibling (n=23 823**)**			
No	878 (3.7)	2 265 (96.3)	23 553 (100)
Yes	39 (14.4)	231 (85.6)	270 (100)
Birth interval to next sibling (months)			
(Mean,SD)	37.1	13.9	4 737
Birth interval to previous sibling (months)			
(Mean,SD)	36.6	14.2	5 217

*** Household head, [1] Variable has some missing values.**

3.2 Mortality rates

There were a total of 23,823 children who contributed a total of 37456.64 person years of observation over a period of 3 years. Figure 3.1 shows the number of deaths per 1000 person years observed for infants, children and under five children overall from 2005-2007. The results show very high mortality during infancy compared to children. There was a slight decline in the overall under 5 mortality between 2005 to 2007 with 26.9, 23.1 and 22.1 deaths per 1000 person years of observation for 2005, 2006 and 2007 respectively.

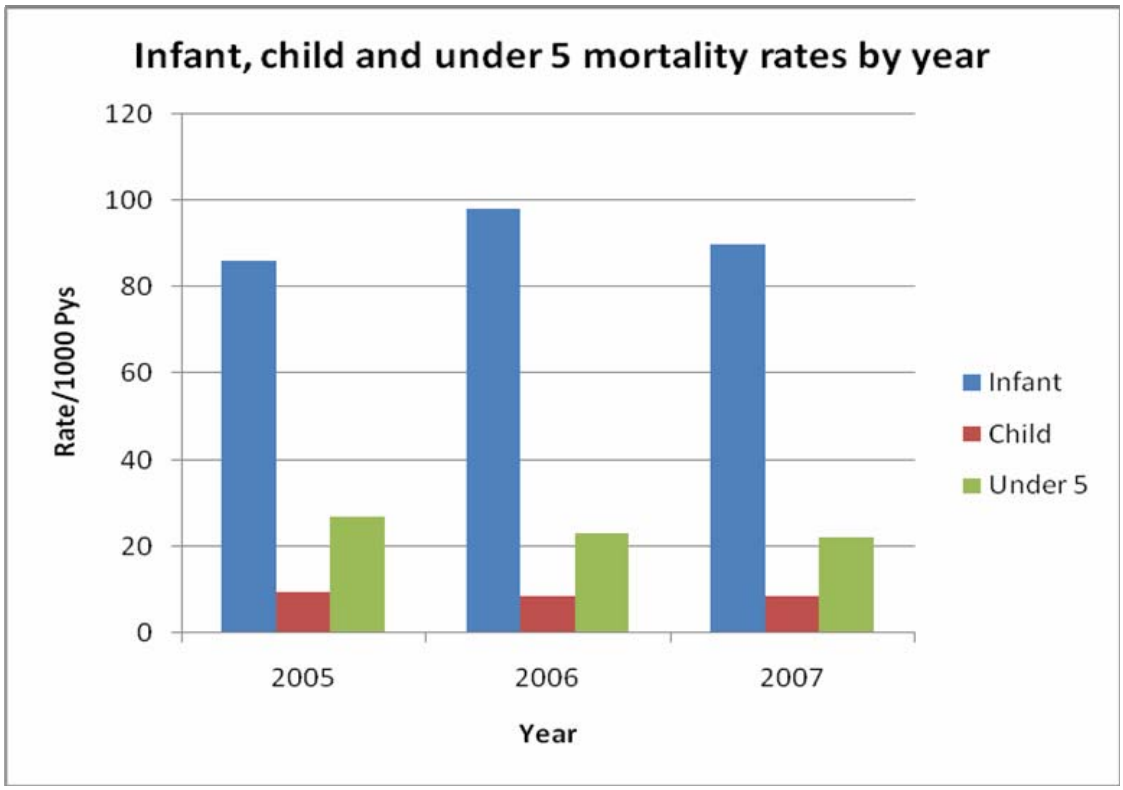


Figure 3.1: Infant, child and under 5 mortality rates

3.3 Cause specific mortality

3.3.1 Top 5 causes of child mortality in IHDSS area

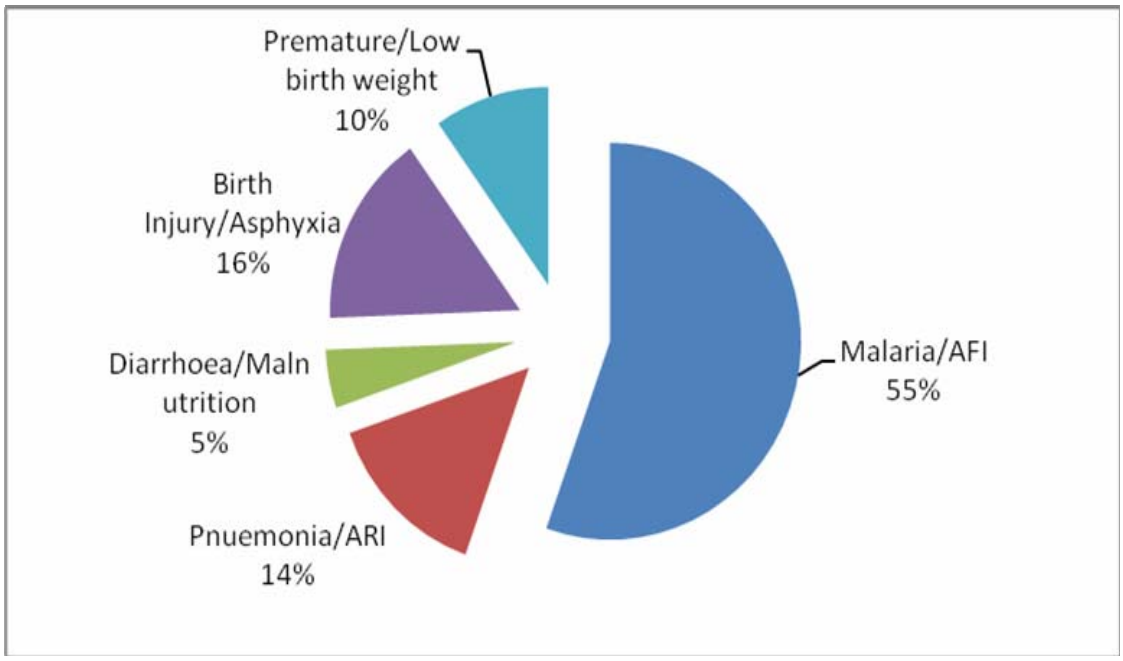


Figure 3.2: Top 5 causes of child mortality in IHDSS area.

Figure 3.2 displays the top 5 causes of under 5 mortality in IHDSS area between 2005-2007. Malaria, pneumonia and birth injury/asphyxia dominate other causes of death in the area with malaria being the outright leading cause of child death 313(55%).

3.3.2 Cause specific mortality rates

Figure 3.3 displays the cause specific mortality rates of the 4 major causes of child deaths in Ifakara, Tanzania. Malaria/Acute febrile illness recorded the highest mortality rate for infants, children and under 5 categories with the infant mortality rate as high as 31 malaria deaths per 1000 person years of observation. Deaths attributed to pneumonia and Acute respiratory infections recorded mortality rates of 9.2, 0.4 and 1.7 per 1000 person years of observation for infants, children and under 5's respectively.

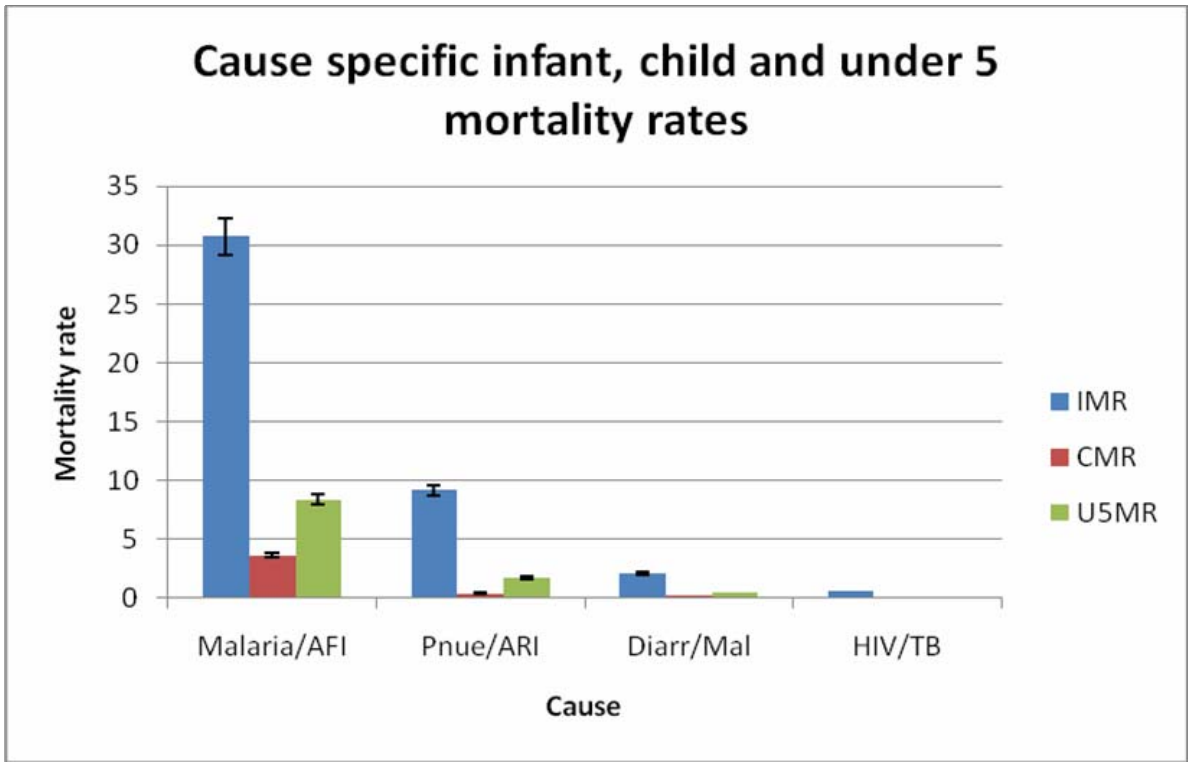


Figure 3.3: Cause specific mortality rates

3.4 Child survival in IHDSS between 2005-2007

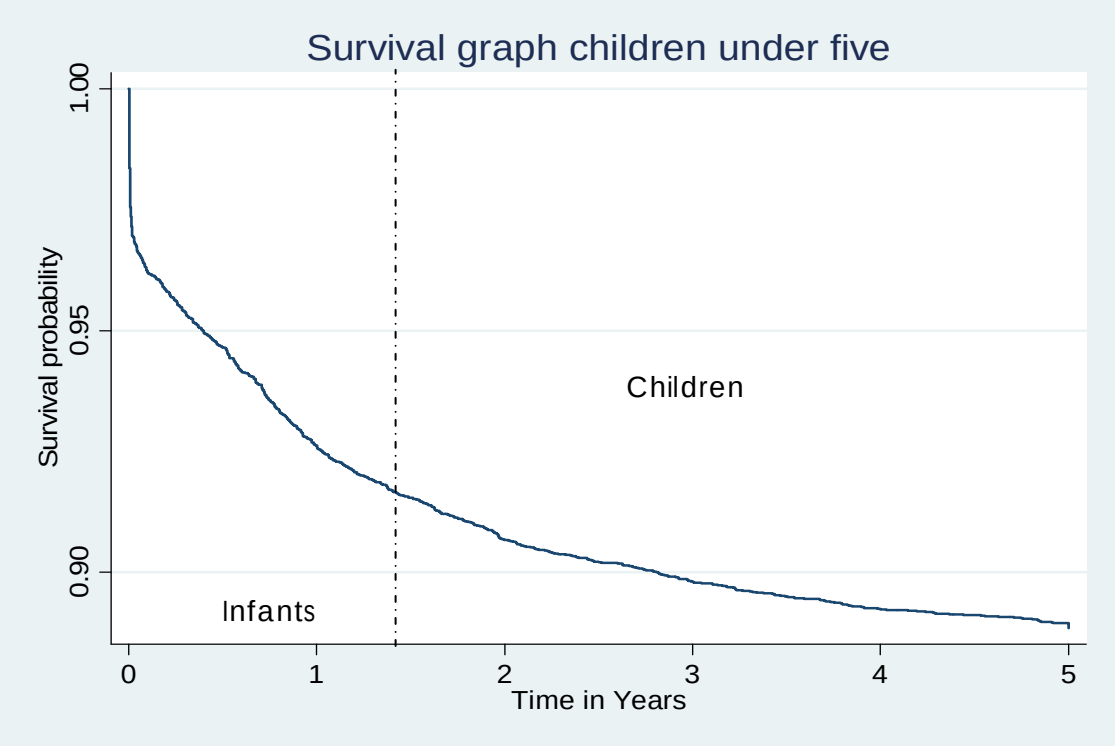


Figure 3.4: Kaplan Meier graph showing overall survival

Figure 3.4 shows the mortality risk faced by under 5 children in the study during the 3 year period. The survival probability drops sharply during the initial infancy when compared to the child (1-4) stage. This is clear evidence that the risk of mortality is most severe during the infant stages of the childhood most especially during the neonatal stage as depicted by the sharp fall of the graph at the beginning. The survival hazard at one year was [0.93; 95%CI 0.920-0.932] and [0.89; 95%CI 0.88-0.90] at 5 years. About 8% of the children died in their first year of life but survival of the children in the study thereafter improved as they entered the child (1-4) stage with 5% deaths recorded in this stage before their fifth birthday.

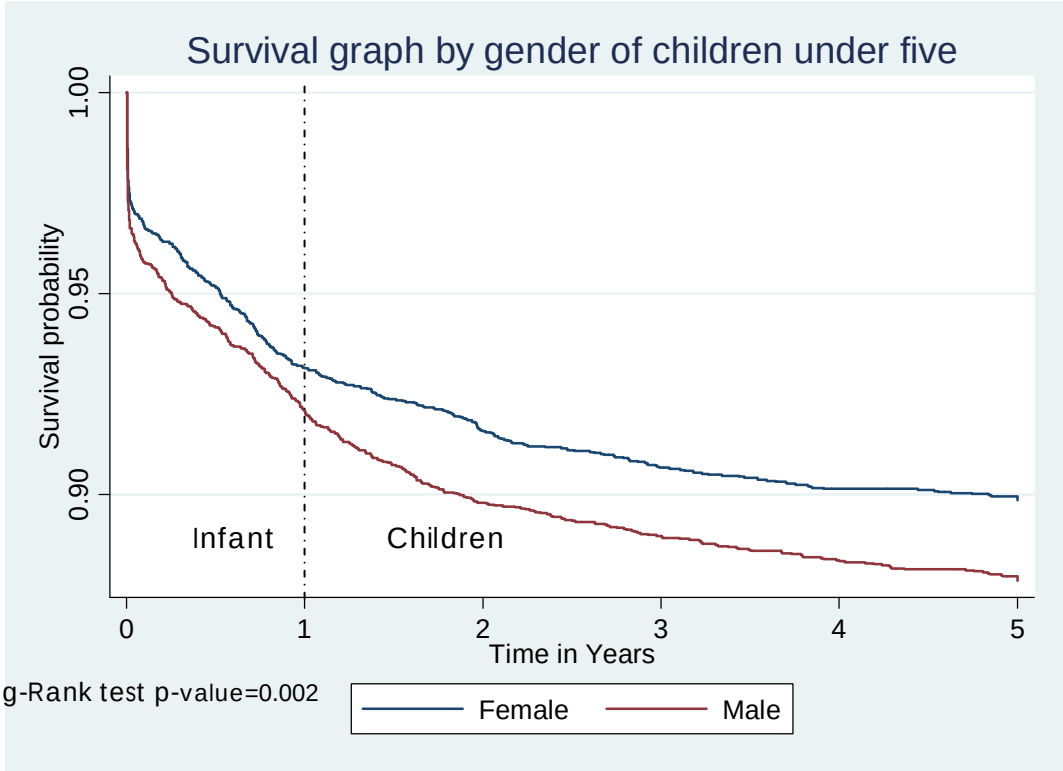


Figure 3.5: Kaplan Meier graph showing survival by gender

Girls had a better survival compared to the boys as shown by figure 3.5. The survival probability was higher at all time points throughout the 3 year study period for females when compared to the males. The difference in the survival probability of male and female children is narrower at the infant stage but becomes more prominent as the children grow older.

3.5 Distance from the child's household to the nearest health facility

Two types of distance from home to the nearest health facility were developed and investigated in this study i.e. Networked distance and Euclidean/Straight line distance.

3.5.1 Euclidean (straight line) distance

There were a total of 13,845 households with recorded straight line distances to the nearest health facility. The mean straight line distance was 4.2KM, SD of 3.9KM with range [0.0, 20.9]KM and median of 2.7KM.The Euclidean distance ranges from 0KM to 20.9KM. Majority of the children 16,027(67%) lived in household that were less than 5 KM

(Euclidean) to the nearest health facility while 7,796(32.7%) lived more than 5KM from the nearest health facility.

3.5.2 Infant and child mortality rates by Euclidean distance

The infant mortality rate for children living less than 5KM straight line distance to the nearest health facility was higher [79.8vs 75.5 per 1000 per years of observation] compared to those living more than 5KM from the nearest health facility as shown by Table 3.2. On the contrary CMR increased as straight line distance to the nearest health facility increased. Children who lived less than 5KM had lower mortality rate [8.0 vs 12.3 per 1000 per years of observation] than those who lived more than 5KM from the nearest health facility.

Table 3.2: Infant and child mortality rates by Euclidean distance per 1000 PYs

	Infants		**Children(1-4)**	
Distance/KM	Rate/1000PYs	95% CI	Rate/1000PYs	95% CI
< 5	79.8	72.6 – 87.8	8.0	6.8 – 9.8
>= 5	75.5	65.7 – 86.9	12.3	9.8 – 15.6

3.5.3 Networked distance

There were a total of 13,845 households with networked distances in the study. The mean networked distance from home to nearest health facility was 8.3KM, SD of 6.8KM with a range [0.0-50.5]KM and median of 7.0KM. The majority of the children 14,558(61.2%) lived more than 5KM (network) to the nearest health facility compared to 9,265(38%) who lived less than 5KM to the nearest health facility.

3.5.4 Infant and child mortality by networked distance

Both the infant and child mortality rates increased as networked distance from health facility increased. Infants who lived less than 5 KM networked distance to the nearest health facility

had a lower mortality rate [72.4vs 82.3 per 1000 person years of observation] when compared to those living greater than 5KM from the health facility. The child mortality rates also followed the same trend, increasing as networked distance to the nearest health facility increased (Table 3.3) with 8.4 and 9.9 deaths per 1000 person years of observation for less than 5KM and greater than or equal to 5KM categories respectively.

Table 3.3: Infant and child mortality rates by networked distance

	Infants		**Children(1-4)**	
Distance/KM	**Rate/1000PYs**	**95% CI**	**Rate/1000PYs**	**95% CI**
< 5	72.4	63.5 – 82.5	8.4	6.6 – 10.9
>= 5	82.3	74.6 – 90.7	9.9	8.2 – 12.0

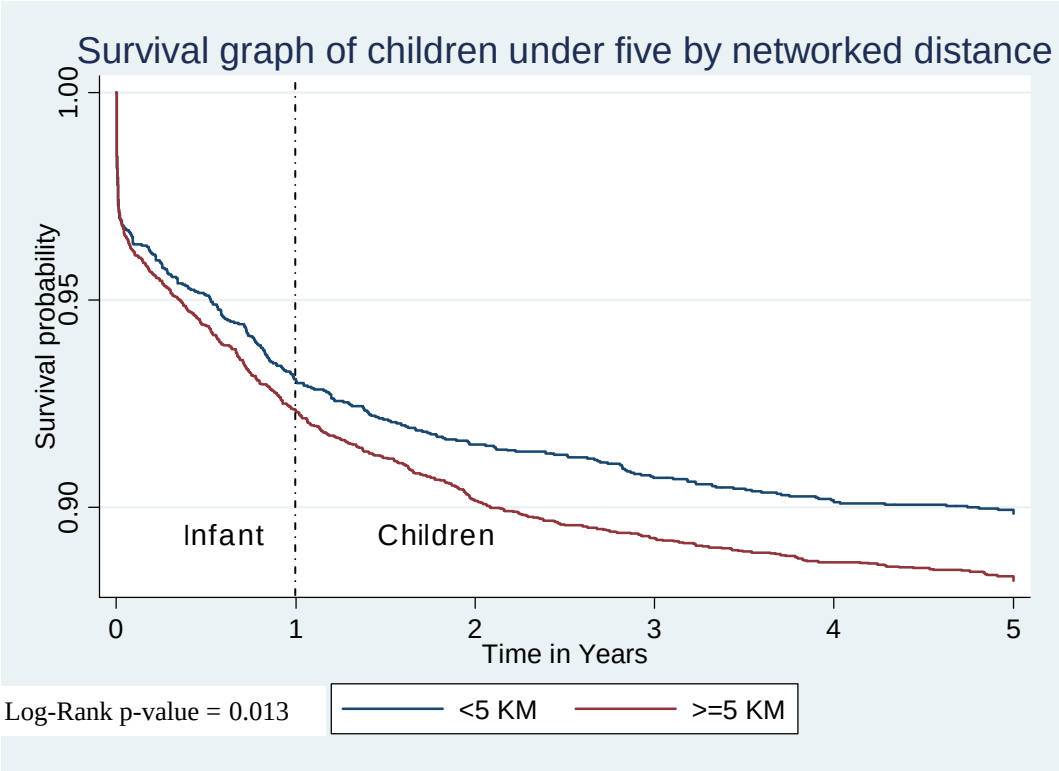


Figure 3.6: Kaplan Meier survival graphs by networked distance

Figure 3.6 shows the survival probabilities of children by networked distance categories i.e. <5KM and >=5KM. The survival probability appeared higher at all time points throughout the childhood years for children who lived less than 5KM networked distance compared to those who lived greater than 5KM networked distance.

The difference between the survival probability of the children who lived less than 5KM and greater than 5KM networked distances to the health facility seems to be bigger during the child (1-4) stage when compared to the infant stage. Which shows that as the children grow older, those who lived greater than 5KM networked distance had a much higher decline in their survival probability when compared to those who lived less than 5KM distances.

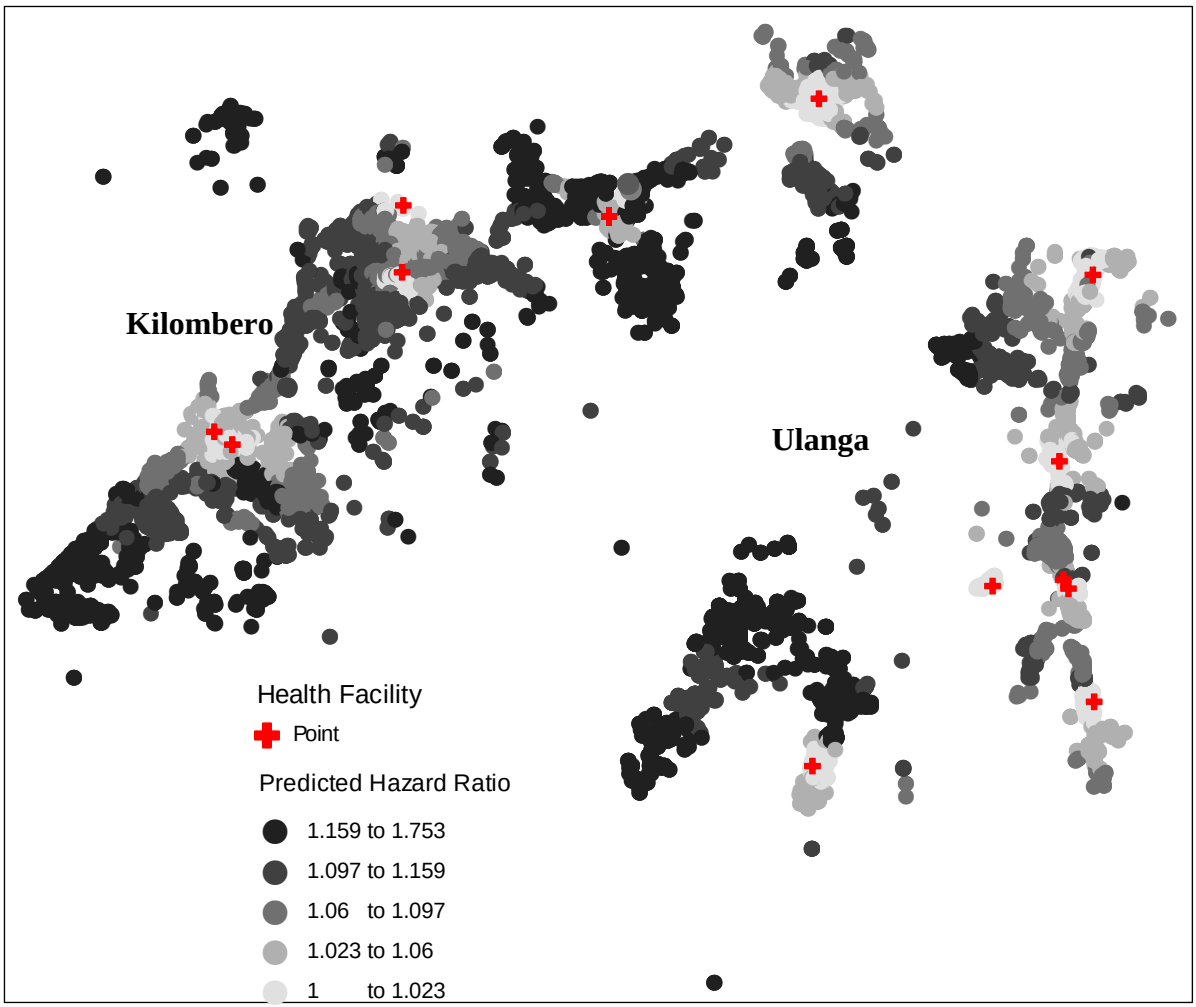


Figure 3.7: Estimated child mortality risk by networked distance in IHDSS between 2005-07.

Figure 3.7 shows that majority of the child death in IHDSS between 2005-07 occurred to children in households who lived far away from the nearest health facility. The child mortality risk increases as the networked distance from home to the health facility increases. Households that were located near the river bank that separates the two districts appeared to experience higher mortality when compared with households that were inland.

3.6 Association of child mortality and distance to the nearest health facility

The Cox proportional hazard regression models were used to investigate the relationship between distances from home to the nearest health facility and childhood morality which was initially stratified by infant and child(1-4) mortality. The two models of infants and children posted similar results in respect to the main independent variables i.e. networked and straight line distance. Therefore the final univariate and multivariate models that are presented are for all under 5 children i.e. infants and children (1-4) combined. The networked distance was selected over Euclidean distance in the final adjusted model because it represents the more realistic distance that a sick child would need to cover to reach the nearest health facility. Furthermore, networked distance showed more consistency during the analysis stage when compared to Euclidean distance. The effect of missing values on the hazard ratios was assessed and no significant differences were found in the hazards of the variables to suggest non random distribution of the missing values.

3.6.1 Univariate model

Univariate Cox proportional regression was carried out to investigate the relationship between under 5 mortality and all explanatory variables as presented in Table 3.4. The level of significance for entry into multivariate model was 10%.

Networked distance from home to the nearest HF was strongly associated with under 5 child mortality. Children who lived more than 5KM networked distances from the nearest health facility experienced 19% CI[1.06-1.33] increased mortality risk when compared to those who lived less than 5KM distance to the nearest health facility.

There was significantly higher risk associated with male children compared to the females. Male children experienced 22% CI[1.09-1.37] increased mortality compared to the female children at 5% level of significance.

Every one year increase in the child's age reduced the risk to mortality by over 50% CI[0.45-0.52] in the study.

There was strong association between mothers' age and under 5 child mortality in the study. The hazard rates show that under 5 child mortality reduces as mothers age increases with children whose mothers were 20-29 year and 30-39 years experiencing over 40% reduced mortality compared to children whose mothers were less than 20 years.

Death of the child's mother showed very strong association ($p<0.01$) with under 5 child mortality in the study. Children whose mothers died during childhood were 4.41 CI[3.34-5.82] times more likely to die when compared to children who still had their mothers alive.

There was a significant association between family size and under 5 mortality. Children who lived in households with more than 3 people experienced an increased mortality of 36% CI[1.22-1.52]compared to those that lived in households with one or two persons.

There was a strong association between mothers' parity and under 5 mortality. Children mother's were at parity 2 to 3 and more than 4 experienced a reduced mortality hazard of 35% CI[0.55-0.77] and 31% CI[0.59-0.81] respectively compared to those children whose mothers' were at parity one.

There was also a statistically significant ($p<0.01$) increased mortality risk for the children of multiple birth when compared to single births (199%).

Death of preceding sibling was strongly associated to child mortality in the study. Children whose preceding sibling had died were 4.5 CI[3.42-5.91] times more likely to die than those whose preceding siblings were still alive.

The study shows that every one month increase in the birth interval to the next sibling reduces the risk to mortality by 10% CI[0.90-0.92].

Table 3.4: Univariate and Multivariate analysis of Under 5 mortality.

	Univariate			Multivariate		
Variable	**HR**	**90% CI**	**P-Value**	**HR**	**95% CI**	**P-Value**
District						
Kilombero(Ref)						
Ulanga	0.97	0.86-1.10	0.62			
Gender						
Female (Ref)						
Male	1.22	1.09-1.37	**<0.01**	1.16	1.01-1.35	**0.05**
Age at start of study	0.49	0.45-0.52	<0.01	0.35	0.29-0.43	**<0.01**
Euclidean Distance						
< 5KM (ref)						
>5 KM	1.08	0.96-1.21	0.3			
Networked Distance						
< 5KM (ref)						
>5 KM	1.19	1.06-1.33	**0.01**	1.17	1.02-1.38	**0.05**
Mothers age						
< 20 (Ref)						
20 -29	0.59	0.51-0.69	**<0.01**	0.93	0.74-1.17	0.54
30 -39	0.59	0.50-0.69	**<0.01**	1.21	0.89-1.64	0.22
> 40	0.32	0.22-0.45	**<0.01**	1.00	0.611-1.64	0.99
Mother Education						
None(Ref)						
Primary	0.91	0.75-1.10	0.40			
Post primary	0.56	0.26-1.19	0.21			
Parity						
1 (Ref)						
2 to 3	0.65	0.55-0.77	**<0.01**	0.61	0.52-0.83	**<0.01**
4+	0.69	0.59-0.81	**<0.01**	0.56	0.52-0.91	**0.01**
Multiple/Single birth						
No(Ref)						
Yes	2.99	2.46-3.63	**<0.01**	2.91	2.27-3.74	**<0.01**
Mother death						
No(ref)						
Yes	4.41	3.34-5.82	**<0.01**	5.87	4.11-8.40	**<0.01**
Birth interval to previous sibling	1.00	0.99-1.00	0.47			
Birth interval to next	0.91	0.90-0.92	**<0.01**			

sibling*						
Death of preceding sibling						
No(Ref)						
Yes	4.5	3.42-5.91	<0.01	1.90	1.37-2.65	**<0.01**
Season						
Rainy(ref)						
Dry	0.95	0.85-1.07	0.49			
Wealth quintiles**						
Poorest (Ref)						
Poorer	0.86	0.71-1.02	0.16			
Poor	0.88	0.73-1.04	0.21			
Less poor	0.91	0.76-1.09	0.38			
Least poor	0.86	0.72-1.02	0.16			
HHH Occupation						
Farming (Ref)						
Causal worker	0.85	0.64-1.12	0.33			
Business	0.95	0.80-1.12	0.61			
Gov't employee	1.09	0.90-1.33	0.44			
Other	0.79	0.59-1.05	0.17			
Family size						
1 -2(Ref)						
3+	1.36	1.22-1.52	**<0.01**	1.30	1.11-1.52	**<0.01**

*****Not included in multivariate because of small numbers.

**Wealth Index showed significant association with child (1-4) mortality though no association existed with infant mortality in the analysis.

3.6.2 Multivariate analysis

In the Multivariate model networked distance was then adjusted for other potentially confounding explanatory variables (gender, age, networked distance, mother age, parity, multiple/single birth, mother's age, death of preceding sibling, family size) that posted significant results in the Univariate model as presented in Table 3.4.The level of significance used to assess variables in the multivariate model was 5%.

Networked distance to the nearest health facility remained strongly associated with infant mortality after controlling for gender, maternal age, mother death, multiple birth, parity, death of preceding sibling and family size. Residing more than 5KM networked distance to

the nearest health facility was associated with 17% increased child mortality compared to those children who lived less than 5KM networked distance to the nearest health facility.

Male children continued to be associated with under 5 child mortality with 16% increased mortality for males compared to female children at 5% level of significance.

Increasing age of the child in years remained protective showing that for every one year increase in the child's age the risk to mortality reduced the by over 65% in the study.

Mothers' parity maintained strong association with under 5 mortality in the adjusted model. Children born to mothers' at parity 2 to 3 and more than 4 experienced a reduced mortality hazards of 31% and 28% respectively compared to children whose mothers' were at parity one.

The mother's age was no longer significantly associated with child mortality in the multivariate model.

Death of the child's mother maintained its strong association ($p<0.01$) with child mortality showing that under 5 children's whose mothers were reported dead were 5.87 time more likely to experience child mortality when compared to those who still had their mothers alive.

Children who lived in households with more than 3 people experienced a significant increase in their mortality hazard of 30% compared to those that lived in households with one or two persons ($p<0.01$).

Multiple births continued to be associated with under 5 mortality in the adjusted model. Children born of a multiple birth were 2.9 times more likely to experience mortality when compared with single births.

Death of preceding sibling remained significantly associated with child mortality. Children whose preceding sibling had died were 1.9 times more likely to die than those whose preceding siblings were still alive. Multiple births in the adjusted model had a confounding effect on both death of preceding sibling and death of mother during childhood.

3.6.3 Cause specific child mortality and distance to the nearest health facility

Models to investigate association between networked distance to the nearest health facility and cause specific mortality were developed. The causes included were malaria/AFI, pneumonia/ARI, diarrhoea/Malnutrition and HIV/TB. There was no evidence in any of the four univariate models to show any association between networked distance to the nearest health facility and under 5 cause- specific mortality in this study.

4 CHAPTER FOUR: DISCUSSION

This study explored association between distance to the nearest health facility and under 5 mortality in IHDSS and the findings from this study provide evidence of a strong association of network distance from home to the nearest health facility and survival of under 5 children in Ifakara HDSS area. The study also showed high infant, child and under 5 mortality rates in the IHDSS area with malaria/AFI and pneumonia/ARI being the first and the second highest killers of children. A number of other risk factors were confirmed to be predictors of Under 5 mortality in the rural Ifakara area of Tanzania with mother death in childhood, death of preceding sibling, mother's parity and multiple births showing the strongest effect on under 5 mortality.

Infant and child mortality rates as shown by the study indicate very high mortality in both infants and children and these were similar to findings from other studies in Tanzania (Morogoro Health Project 2006;NBS & ORC Macro. 2005;Schellenberg et al. 2008) that found similar figures of infant and child mortality. This is testimony to the fact that childhood mortality in SSA remains high compared to other parts of the world despite recent reported declines in child mortality in Tanzania and SSA as a whole (Masanja et al. 2008;Murray et al. 2007;Valerie et al. 2001). Declines in the child mortality rates can be explained by the successful large scale immunization programs, Vitamin A supplementation and oral rehydration drives that have been run by various SSA countries but more is still required if the child mortality rate of western countries of about 7 for every 1000 children by 2002 is to be taken into consideration.

The high rates of all cause child mortality highlights cause specific mortality issues in the area as shown by the study. Malaria continues to be the number one killer of both infants and

children in Ifakara due to it's being a highly endemic malaria transmission region killing 31 out of every 1000 infants and 7 out of every 1000 under 5 children in the study. Other leading causes of infant and child deaths in the study were acute respiratory illnesses, diarrhoea, malnutrition and HIV/TB. Similar leading causes child mortality are reported by (Alexander et al. 2006;Kasumpa 2005;Sacarlal et al. 2009) in SSA settings where malaria and HIV/AIDS continue to have a devastating effect on mortality of both children and adults. HIV positive mothers still continue to deliver infected babies which keep the HIV/AIDS child mortality high despite the introduction of PMTCT practices at majority of health facilities. Absence of clean safe water and poor sanitation are still the main cause of high diarrhea incidence in Ifakara and many other SSA settings. The high infant and child mortality rates in the study were variable by all the risk factors that were confirmed to be independent predictors of under 5 mortality.

Male children had higher infant and child mortality rates compared to the females. Infants and children born to teenage mothers and mothers with no education were at particularly higher risk, just as those born to mothers at parity one (NBS & ORC Macro. 2005).

Many studies (Binka et al. 1995;Gemperli et al. 2004;Hammer et al. 2006;Mturi & Curtis 1995;Vella et al. 1992) have documented the major risk factors for child mortality especially in SSA. In this study similarly, gender, multiple birth, maternal death, death of preceding sibling and family size were found to be significantly associated to increased child mortality risk while age of child, maternal age, parity and birth interval to next sibling were also confirmed to have a protective effective on the under 5 mortality in the study.

The strong association of mother death during childhood by the study was also found in studies in SSA (Becher et al. 2004;Hammer et al. 2006) which underlines the big role mothers have to play in the survival of children. (Quinn 1996) estimated that for every

mother death to HIV, there a two orphaned children and with the current HIV epidemic devastating SSA, mothers are just as likely to suffer from death which could possibly explain the high childhood mortality in these areas.

Multiple births in the study experienced almost 190% excess mortality compared to single births and this was also be reported by (Becher et al. 2004;Justesen & Kunst 2000). In a study in southern and eastern Africa, (Justesen & Kunst 2000) demonstrated the magnitude of excess mortality for twins births over single births though the excess mortality was largest during the first year of life. Mothers are usually overwhelmed by the extra responsibility multiple births demand, with some mothers suffering from insufficient breast milk which reduces the immunity of the babies in the early stages of life leading to the high child mortality incidence.

Both measurements of distance appeared to have a more consistent effect on child mortality rates than infant mortality rates. The infant mortality rates under the Euclidean distance tend to reduce as the distance to the health facility increases which is in direct contrast to infant mortality under the networked distances. This could be attributed to the fact that Euclidean distances are hypothesized travel distances to the nearest health facility unlike the networked distance measures that are the more actual travel distances to the health facility. Although Euclidean and networked distances are strongly correlated as shown by the study, variations still exist especially in suburban and rural areas. Major errors are likely to be introduced and it's recommended that in measuring distances in rural areas network based distance may provide the best estimates for purposes of health research (Philippe et al. 2008).

The study developed two measures of distance with the Euclidean distance giving an average distance of 4.2 KM from home to the nearest health facility while the average networked distance was 8.3 KM. The difference is due to the fact that the networked distance

measurement in the study followed through the real paths or roads that an ill child would probably follow to the nearest health facility which is much longer and more realistic as compared to the Euclidean distance to the health facility. Overall Euclidean distance posted a great deal of inconsistent results with infant and child mortality unlike the networked distance. Networked distance has been reported to be useful in evaluating the probable path used on foot or bicycle between two points (Brabyn & Skelly 2002) which is the likely mode of transport found in rural Tanzania. Distance in the study was investigated in two main categories i.e <5KM and >=5KM and this was in line with other studies in SSA that have retained the categorization (Debpuur et al. 2005;Thaddeus & Maine 1994). The study found more than half of the children lived more than 5 KM networked distances to the nearest HF which does not conform to earlier studies which reported that three quarters of the rural population in Tanzania live within 5KM distances of the nearest health facility (Health Research for Action 2006;Schellenberg et al. 2008). These distances, in many cases are reported distances by the respondent and are very prone to bias unlike the networked distance in this study which provided more exact bias free estimates of distances from home to the nearest health facility. The mode of transport, social economic status and the seasonality of the roads to the health facility have been reported to confound the accessibility to health care in rural areas and provides further proof that distance is only one aspect of unequal access to health care. Poverty and availability of care givers and drugs in health facilities have continued to affect the quality of care at the health facility however near the health facility is to the population(Mahmud et al. 2006). Owning a bicycle to ease accessibility of health facilities which are the basic source of health care for the rural populations in Tanzania is a wise investment especially in times of emergency. As shown by the study, child mortality was higher for children in households that lived far away from the nearest health facility (figure 3.7) although it is widely understood that the availability of a health facility does not

necessarily translate to adequate access or quality health care(Mahmud et al. 2006). This is especially true among households living in extreme poverty in rural areas like Ifakara.

This study found evidence that distance to the nearest health facility affects under 5 survival. The effect is more consistent with the networked distance which shows about 20% increased mortality for under 5 children staying more than 5KM networked distance to the nearest health facility. These findings comply with earlier studies (Frankenberg 1992;Hammer et al. 2006;Kasumpa 2005;Katende 1994;Schellenberg et al. 2008) that reported similar effect of distance to the nearest health facility on child mortality in SSA. (Hetzel et al. 2008) reported frequent seasonal movement of parts of the population to their distant fields (Shamba home) which resulted in an increased mortality risk especially due to malaria in Ifakara. During the harvest period over 60% of the household especially adults (over 16 years) and children below five years spend most days and nights in the *shamba* whose accessibility to health facilities especially in times of emergency is limited due to the longer distance.This finding re-emphasizes the usefulness of having fully functional health facilities closer to the populations that need them. Access to the health facility is not usually the only problem faced by health seekers as often it has been reported (Kasumpa 2005) that it usually takes between 30-60 minutes to be seen by a help professional. It also reported that delayed health care seeking by mothers of sick children can be attributed to the time it takes to travel to a health facility and delays in being attended to. A study in southern Tanzania (Schellenberg et al. 2008) revealed particular problems with staff absence, drug stocks and that only about one fifth of the health facilities had a reliable water supply. When the children were stratified into neonates and infants, there was no evidence of increased mortality in any of two categories although for neonates this could be attributed to the extra care and attention given by mothers and medical staff. But as the child gets older, the effect of distance on their survival increases

as shown by the study. There was no association found in the study when networked distance to nearest health facility was investigated as an independent predator of cause specific mortality but this could be partly attributed to the small numbers in the investigated causes.
An increasing number of health studies have integrated GIS techniques in calculation of shortest distance, networked distance, least cost distance, etc but as shown by this study, results may vary depending on the type of distance estimated and aggregation method used which may have implications on the results of the study (Apparicio et al. 2008).

The child mortality risk in IHDSS area seemed to be higher in Kilombero than Ulanga district although this could be attributed to the difference in size and population between Kilombero and Ulanga. There was also higher morality experienced by households next to the river bank which households were quite far from the nearest health facilities in both districts. Ulanga district of the two districts had a more even distribution of the health facilities when compared to Kilombero and this could also be the reason for the higher morality in Kilombero when compared to Ulanga districts in the study. The high mortality areas in the south of Ulanga district is linked to pastoralist population who are very mobile and usually stay far away from health facilities.

4.1 Limitations

The networked distance to the nearest health facility provided the study with the best estimation for geographical accessibility under the circumstances since there was no reliable data on transport means, seasonality of the roads, speeds limits and geographical barriers like rivers and lakes.

The study used secondary data analysis and therefore was limited to variables that were present in the dataset. Factors like marital status, religion and health facility based variables like drug and vaccine stock, number of staff, availability of water could have heavily

enriched the results of the study. Secondly reliability and validity of the study results heavily relies on how well the data was collected by the IHDSS field staff.

Households that dissolved in 2005 before the start of geo referencing of all households in 2006 in the DSA could introduce some bias in case the dissolutions were not random.

Household with children legible for this study that had missing geo reference data were not included in the analysis. However, there were no significant differences in the social demographic composition of children in the geo referenced and no geo referenced households suggesting limited or no selection bias.

Verbal autopsy was used ascertain the probable cause of death of the study participants using information on symptoms and signs gathered during bereavement interviews of persons who were caring for the deceased. Though VA's procedures are growing in importance in areas that lack reliable mortality data like the SSA, there are still issues with its validity assessing the cause of death due to recall bias and misclassification of deaths during the coding process (Setel et al. 2006).

Most of the households in IHDSS have a second home called shamba that is located in the planting fields and during the harvesting period over 60% of the household members of farming households move to the shamba homes. The shamba are likely to have poorer access to health facilities and other infrastructure and because these houses were not geo referenced, they were not included in the study.

Geo referencing of all the households in IHDSS was done using the Garmin eTrex GPS units which has an accuracy of 10 metres. The accuracy of the GPS unit could have distorted the true distance from home to the nearest health facility which could have affected the study results.

The study assumed that people always make use of the nearest health facility when in search for health care which is not necessarily true to some people.

4.2 Strength of the study

The large population under study in IHDSS and the rigorous demographic surveillance system which continuously capture vital population statistics (mortality, births and migration) provided reliable person-time at risk that enabled the computation of accurate mortality estimates in the study.

The ability to compute networked and Euclidean distances from home to the nearest health facility provided the study with a more objective way of analysing distance compared to reported distances or time by respondents which are susceptible to bias and error.

5 CHAPTER FIVE: Implication of study and conclusions.

5.1 Implications of the study

Euclidean distances are strongly correlated to networked distances as shown by the study but variations still exist and they could be heavily compounded by the aggregation method used. For more reliable and consistent results the networked distance estimation should be the preferred option especially if it involves evaluating probable paths and roads used in foot (Brabyn & Skelly 2002).

Estimation of distances as a proxy for accessibility of health care has been made tremendously easy with the availability of GIS network analyst tool and with current speeds of computers, numerous network distances can be calculated in a very short time as shown by this study.

As shown by this study under 5 mortality is still high and generally many people including health policy makers continue to attribute the high mortality rates to mainly the presence of HIV/AIDS and malaria in the population. Factors like access to health facilities, availability of drugs and staff continue to be given less attention despite their contribution to the exiting mortality burden. For MDG 4 targets to be achieved issues of effective delivery of interventions need to be given as much attention. (Bryce et al. 2003) says “Savings a child’s life requires both an effective intervention and a way to the intervention to the mothers and children who need them (The delivery strategy)”

Improving access to interventions by improving on the geographical accessibility (road and transport) of health facilities in the rural areas may help to improve child survival, reduce mortality and morbidity in the population. With three quarters of the population living within 5KM distances to the health facility, paving roads and availing ambulances for emergency

could heavily improve child survival. This could be a major mechanism through which the problem of in-access of HF for interventions could be tackled.

The Tanzanian Ministry of health should explore the possibility of running a campaign to improve availability and accessibility of intervention like anti malaria, oral rehydration drugs, Vitamin C supplementation at the village or ward level through community based drug agents or localized trained nurses who are based in the community, can easily prescribe drugs and are very accessible to the population in an effort to reduce childhood mortality(Wells Pence et al. 2007).

There is urgent need to improve geographical access to health to the majority of the impoverished populations in rural Tanzania. Establishment of more health posts that are fully stocked and operational nearer to the community could bear fruit especially with reducing emergency related death for child and pregnant mothers. Both Kilombero and Ulanga districts urgently need more health posts especially towards the river bank which appeared to have higher child mortality when compared to the inland.

There is need for future studies to assess not only distance but also quality of health care given by the nearest health facility on child mortality.

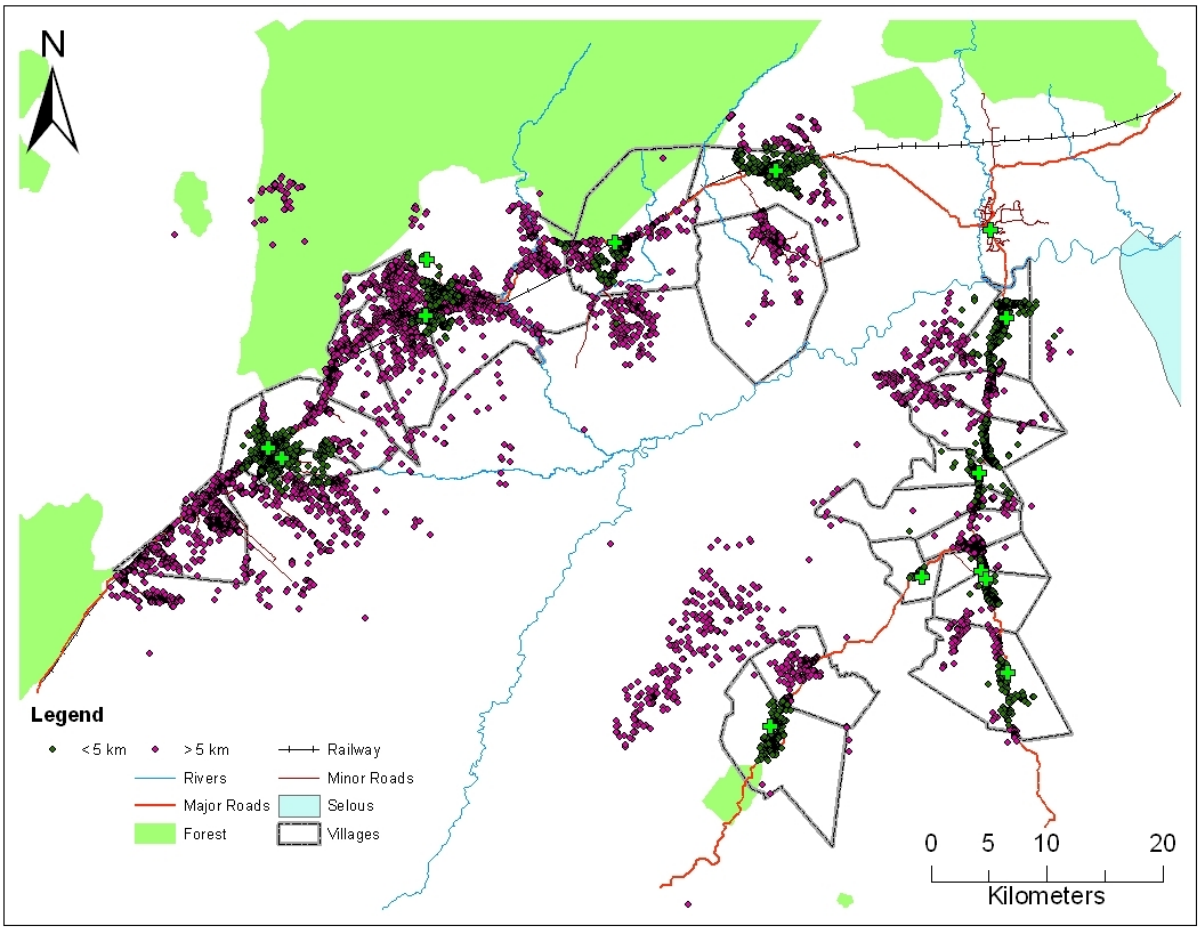
The government and NGO’s should avail free or heavily subsidize and promote insecticide treated mosquito nets to populations in malaria endemic areas like Ifakara and southern Tanzania whose malaria mortality burden is still very high.

The Tanzania government through the area local governments should prioritize provision of clean and safe water to the communities that still record high diarrhea prevalence and mortality in children. Communities should further be educated on the benefits of drinking boiled water and keep their environment clean.

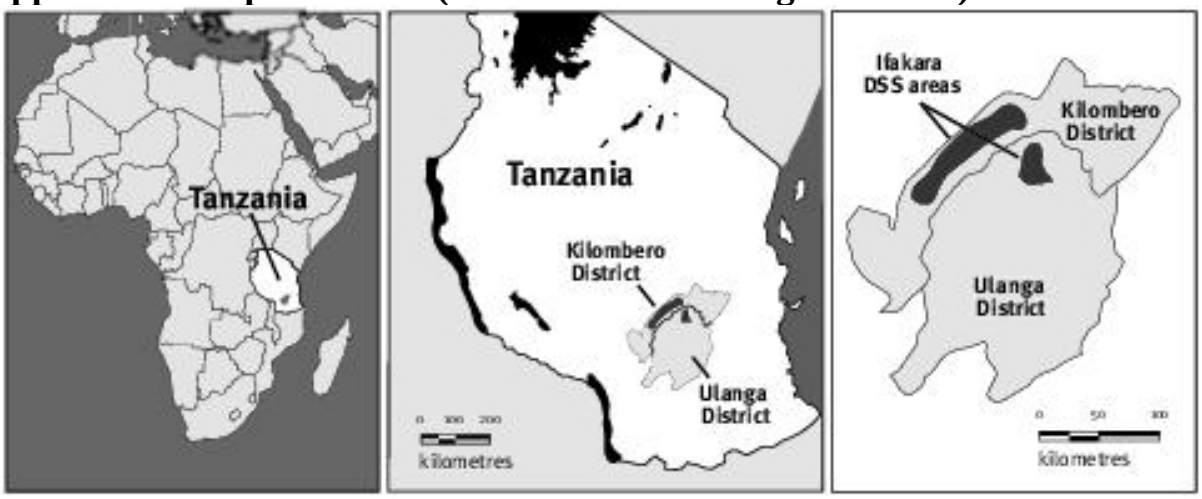
5.2 Conclusions

This study confirms that there is a broad set of factors that are acting together or independently to explain the higher child mortality rates in SSA. Distance to health facilities appears to be a key predictor of child mortality as confirmed by this and other studies. Distance has been documented as a barrier to utilization of the available health care and the Government of Tanzania urgently needs to look at introducing more health posts that are as closer to the people that need them. These health posts also need be high quality in terms necessary drugs and health personnel to deliver the interventions to the children. If these recommendations are followed, child mortality in Ifakara and other rural areas could drop significantly in a very short time.

Appendix I: Map of HF and population distribution by networked distance.



Appendix II:Map of IHDSS (Kilombero and Ulanga Districts)



Appendix IV: Wits Human Research Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Daniel

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080973**
PROJECT	The Effect of distance to Formal Health Facility on the Child Mortality: Case of Ifakara Demographics Surveillance System in Rural Tanzania
INVESTIGATORS	Mr K Daniel
DEPARTMENT	School of Public Health
DATE CONSIDERED	08.09.26
DECISION OF THE COMMITTEE*	

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE **CHAIRPERSON** .....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Mr B Sartorius

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix V: Permission to use IHDSS data.

IFAKARA HEALTH INSTITUTE
research | training | services

7 September 2008

Mr. Kadobera Daniel
University of Wits
Public Health School
Johannesburg

Re: Permission and conditions to use selected DSS data

The Ifakara HDSS data is a sole property of the Ifakara Health Institute. Mr Kadobera Daniel, a student at the Wits University in SA is granted access to part of the Ifakara HDSS data within the collaboration of the University and IHI (formerly known as IHRDC-refer to the MOU). The data to be made available to Mr. Kadobera Daniel is strictly that contains the variables for the analysis of **"The effect of distance to formal health facility on childhood mortality: Case of Ifakara DSS"** for years 2005-2007.

The following conditions have to be adhered to:

- Use of the data is strictly limited to the purpose of the mentioned study and only for the fulfillment of his academic requirements.
- The work is done under the supervision of IHI scientist, Mr. Mathew Alexander
- All resulting publications will be co-authored and Ifakara will be clearly indicated as the institution that sourced the data

Dr Rose Nathan
For the Director, IHI

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