UNIVERSITY OF THE WITWATERSRAND

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

**RESEARCH REPORT**

**PROJECT TITLE**

# FACTORS ASSOCIATED WITH MORTALITY FROM CHILDHOOD MALARIA IN NAVRONGO DSS SITE, GHANA, 1995-2000.

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Research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfillment of the requirements for the Degree of Master of Science in Medicine in the field of Population Based Field Epidemiology

Financial support for this training was provided by the UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR)

**DECLARATION**

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

Signature: ______________________________

Full Name: **Victor Chalwe F.**

**16th February, 2007**

# DEDICATION

DEDICATED TO

***MY LOVING FAMILY***

FOR THE UNLIMITED SUPPORT

AND

ENCOURAGEMENT I RECEIVED FROM ALL OF YOU

ESPECIALLY MY WIFE AND MY TWO DAUGHTERS FOR THE DAYS THAT

YOU HAD TO BE WITHOUT ME

**ACKNOWLEDGEMENT**

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*Malaria* – is a disease caused by the presence of the protozoan *plasmodium* in human or other vertebrate red blood cells and is transmitted to humans by the bite of an infected female mosquito of the genus Anopheles, which previously sucked the blood from a person with malaria. (Stedman's medical dictionary, 25th international edition)

*Child mortality* **(4q1):** the probability of dying between exact ages one and five

*Under-five mortality* **(5q0):** the probability of dying between birth and exact age five.

All rates are expressed per 1,000 live births, except child mortality, which is expressed per 1,000 child years.

## ACRONYMS

| | | |
|---|---|---|
| CI | : | Confidence Interval |
| DFID | : | Department for International Development |
| DSS | : | Demographic Surveillance System |
| GDHS | : | Ghana Demographic and Health Survey |
| IMCI | : | Integrated Management of Childhood Illnesses |
| IPT | : | Intermittent Preventive Treatment of malaria |
| IRB | : | Institutional Review Board |
| ITNs | : | Insecticide Treated Nets |
| MDGs | : | Millennium Development Goals |
| MoH | : | Ministry of Health |
| MSc | : | Master of Science |
| NHRC | : | Navrongo Health Research Centre |
| RBM | : | Roll Back Malaria |
| RRR | : | Relative Risk Ratio |
| SES | : | Socio Economic Status |
| TDR | : | Tropical Diseases Research |
| UNDP | : | United Nations Development Program |
| UNICEF | : | United Nations Children's Emergency Fund |
| VA | : | Verbal Autopsy |
| WHO | : | World Health Organization |

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**ABSTRACT:**

TITLE: Factors Associated With Mortality From Childhood Malaria In Navrongo DSS Site, Ghana, 1995-2000

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**Background:** Malaria is endemic throughout Ghana and continues to be a major public health concern especially among pregnant women and children under the age of five. The Ministry of Health (MoH) estimates that over the past ten years, there have been 2-3 million cases of malaria each year, representing 40 percent of outpatient cases, while severe malaria accounts for 33-36 percent of in-patients. Malaria also accounts for 25 percent of the deaths in children under the age of five (GHS, 2001).

Correct identification of risk factors could focus interventions at reducing malaria mortality in children. Demographic Surveillance System (DSS) sites have been established and they generate high quality population based longitudinal health and demographic data. The DSS conduct Verbal Autopsies to determine probable causes of death.

**Objective:** This study examines factors affecting childhood malaria mortality in Northern Ghana, using longitudinal data collected by the Navrongo DSS during the period 1995-2000. It deals especially with the role of socioeconomic factors (mother's education, family wealth index based on the possessions and housing characteristics and residence, and possession of bed net) and the demographic characteristics (child's sex and age, and mother's age).

**Design:** Secondary data analysis of longitudinal data collected by the Navrongo Health Research Centre. Multinomial logistic regression was used to compare the relative risk in three groups of children i.e. those who died of Malaria and those who died of other causes to those who survived as base.

**Results:** Overall, for the deaths due to malaria, older children (1-5years) had a higher risk (RRR 1.4, 95%CI 1.25-1.57 P <0.0001) of dying compared to the infants. Equally, children born of older mothers (maternal age at birth of child >30 years) had a higher risk (RRR 1.28, 95%CI 1.15-1.42 P <0.0001).

However, maternal education and residence had a protective effect, with children born of mothers who had some education (RRR 0.79, 95%CI 0.67-0.93 P=0.004) and residing in urban area (RRR 0.61, 95%CI 0.46-0.82 P=0.001) having a lower risk. Similarly, those children whose families are in the highest wealth index had a lower risk (RRR 0.76, 95%CI 0.63-0.91 P=0.003).

Interestingly, the same factors were associated with deaths occurring due to other causes, but with varying degree of association. Whereas sex of child was not associated with malaria deaths, being female offered a lower risk of dying from other causes (RRR 0.9, 95%CI 0.84-0.98 P=0.017). It was observed that children in the older age group (1-5 years) were at higher risk of dying (RRR 1.14, 95%CI 1.05-1.25 P=0.002) just as those born of older mothers (RRR 1.16, 95%CI 1.07-1.26 P <0.0001). Even in this group, maternal education (RRR 0.87, 95%CI 0.76-0.98 P=0.023), a higher wealth index (RR 0.87, 95%CI 0.77-0.99 P=0.032 and RRR 0.63 95%CI 0.54-0.73 P <0.0001 for the two highest categories of wealth indices respectively), and area of residence (RRR 0.67, 95%CI 0.55-0.83 P <0.0001) offered a reduction in the risk of dying.

**Conclusion:** The study identified the risk factors (age and sex of the child and mother's age, maternal education, wealth and residence of the family) associated with malaria mortality and other causes of death in childhood in northern Ghana and this should help formulate cost effective interventions such as health education.

Key words: Infant, Childhood, Malaria mortality, Demographic surveillance system, socioeconomic factors, northern Ghana

# CHAPTER ONE: INTRODUCTION

## 1.1.General Overview

Malaria kills between 1.1 and 2.7 million people worldwide each year, of which about 1 million are children under the age of 5 years in sub- Saharan Africa[1]. As in many other African nations in the tropical region, malaria is the leading cause of death in Ghana for children under five and in 2000, World Health Organization (WHO) estimated a malaria mortality rate of 448 per 100,000 for children under five[2]. Malaria is endemic throughout Ghana and continues to be a major public health concern. It is one of the leading causes of morbidity and mortality, especially among pregnant women and children under the age of five. The Ministry of Health (MoH) estimates that over the past ten years, there have been 2-3 million cases of malaria each year, representing 40 percent of outpatient cases, while severe malaria accounts for 33-36 percent of in-patients. Malaria also accounts for 25 percent of the deaths in children under the age of five[3]. Mortality in the Kassena-Nankana district is very high. The infant mortality and under five mortality rates for 1999 are estimated at 90 per 1000 live births and 150 per 1000 children under five respectively[4]. Malaria remains the top cause of mortality in the district.

Since 1999, Ghana has been involved in international efforts to control malaria under the Roll Back Malaria (RBM), a WHO initiative. The objectives of RBM are to ensure that by the year 2005 at least 60 percent of those at risk of malaria, particularly pregnant women and children under five, have access to the most suitable and affordable combination of personal and community protective measures such as insecticide treated mosquito nets (ITNs) and prompt, effective treatment for malaria. Another objective is to ensure that at least 60 percent of all pregnant women who are at risk of malaria, especially those in their first pregnancies, have access to chemoprophylaxis or intermittent preventive treatment (IPT).

The risk factors associated with malaria deaths especially in rural setting remains unclear. Correct identification of risk factors could focus interventions at reducing malaria mortality in children.

**1.2 Demographic Surveillance System**

Demographic Surveillance System (DSS) sites have been established as a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area. Unlike a cohort study, a DSS follows up the entire population of such a geographic area. The Demographic Surveillance Systems (DSSs) provide the ideal platform for health researchers all over the world to analyze trends in the specific causes of deaths, illnesses, births and migration, thus enabling them to understand the causes and context within which diseases occur for health policy-making. Until the national registration systems of vital events such as births, deaths, marriages and migration trends become more effective and widely used in poor countries, demographic surveillance systems would continue to be the most practical alternatives for gathering data on population and health issues[5].

## 1.3 Research Question

Is there an association between demographic and socio-economic factors with childhood malaria mortality, and can we use demographic surveillance system data to demonstrate this relationship?

## 1.4 Null Hypothesis

Socio-economic and demographic factors are not associated with childhood related malaria mortality in Kassena-Nankana District (Navrongo DSS), rural Ghana.

## 1.5 Justification

Childhood mortality in general and infant mortality in particular is often used as a broad indicator of social development or as more specific indicators of health status. Studies of its characteristics such as age pattern and socio-economic and demographic differentials are used to highlight factors that promote child survival as well as those that are detrimental to it. Consequently, mortality analyses are helpful in identifying promising directions for health programmes and advancing child survival efforts.

Hence, there is need to utilize data collected using verbal autopsies and linking it to demographic and socio-economic characteristics of the population in order to identify risk factors that contribute to malaria mortality in childhood. Risk factor identification help formulate cost effective interventions such as health education and insecticide treated nets promotion. This will help achieve goals of the centerpiece of Ghana's national health policy, "Partnership for Health: Bridging the Inequality Gap." The central objective of this policy is to improve health care for Ghana's poor. This is also in line with the Millennium Development Goals (MDGs) 4 and 6.

This study will use the 1995-2000 data since the data has been cleaned. The latest data (2002-2005) is not yet cleaned.

**1.6 Literature Review**

Africa faces a great challenge to respond timely to the international calls and support on issues of health affecting its masses. Apart from the Roll Back Malaria (RBM) initiative, the United Nations declaration of the Millennium Development Goals (MDGs) is yet another milestone should it be realized.

The UN target under the MDGs is the reduction of under five mortality by two thirds of their current rates. Further the member states have been urged to have by then, halted and begun to reverse, the scourge of malaria and other major diseases that afflict humanity. Malaria has been highlighted because of the impact it has had on both the health of children and pregnant mothers. Malaria is the largest single cause of hospital attendance, the second largest cause for hospital admissions and one of the leading causes of hospital deaths. The profile of western African countries, including Ghana showed that, for the under five children, 35% of outpatient visits were due to malaria, and malaria accounted for 35% of the hospital admissions, while death in the hospitals due to malaria was 30%[6]. In Ghana, the main malaria parasite is *Plasmodium falciparum*. The duration of the transmission is throughout the year in the Southeastern part of the country. In other parts of the country where the transmission is seasonal, it occurs from January to December with duration of 6-10 months. The population at risk of malaria is 100% and malaria is endemic through out the whole country[7].

In the northern Ghana, the area hosting the Navrongo DSS, Malaria is holoendemic[8] and is the most important cause of morbidity and mortality[9]. In a study examining seasonal malaria attack rates in northern Ghana, Kevin BJ et al found in infants and young children an incidence density of parasitemia, after radical cure, of 4.7 infections/person-year during the dry season and 7.1 during the wet season and the prevalence of parasitemia was 69% and 52% in the dry and wet season respectively[10].

Comparatively, in other African countries south of the equator, Salum FM et al in a pilot study in rural Tanzania found 36% of child mortality (1-4 year olds) attributed to Malaria. The results were discussed in relation to other studies in East and West Africa, and to the prospects for reducing mortality through the use of insecticide impregnated bed nets[11].

In another cohort study in Cameroon, Kuate Defo B demonstrated that Malaria contributed to over 10% of all infant mortality (followed up 2 years). Further it was found that malaria mortality co-varied with dwelling conditions, antenatal care attendances, parity, infant feeding practices, intercurrent infections, and child's immunization status. The study concluded that malaria may have a far more significant impact upon infant and early childhood health survival and hence the need for the competing risks analysis in particular for cause-specific mortality differentials[12].

According to the fifty-fifth session of the General Assembly (2000), the UN declared to ensure that by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling and that, girls and boys will have equal access to all levels of education. This declaration will have a bearing on maternal education and consequently expected to impact child survival (as it has been demonstrated in various studies that maternal education is critical to child survival). Bloland P et al in a cohort study in rural Malawi, found the combination of low education and low socio-economic status of the mother (hazard ratio=2.6) to be predominant risk factors for mortality occurring during the second year. The paper emphasized the need for improved delivery of health care and education to women during pregnancy as this may help reduce the burden of early childhood mortality[13].

Poor people are at increased risk both of becoming infected with Malaria and of becoming infected more frequently. All cause child mortality rates are known to be higher in poorer households and malaria is responsible for a substantial proportion of these deaths. In a DSS in rural United Republic of Tanzania, under-5 mortality following acute fever (much of which would be expected to be due to Malaria) was 39% higher in the poorest socio-economic group than in the richest[14].

In a study in DSS site in Burkina Faso, Becher et al, showed that for all cause mortality in children, the age of the mother has a significant impact independent of the order of birth. Both low age (<18) and high age of mother (> 36) was associated with an increased risk[15]. In one study looking at all cause childhood mortality, Jean-Francois et al, observed that over the study period, infant mortality among boys was higher than in girls. This effect was significant during the neonatal period and the post-neonatal period [16]. No effect of gender in the other age groups/periods reached statistical significance. This study will therefore explore this association in case of cause specific mortality.

Most of the targets set for progress on MDGs are benchmarked for the period 1990 to 2015. In order to achieve this on time and monitor progress Africa will have to rely on available capacity to continue identifying modifiable risk factors and implement interventions to reduce childhood mortality in general and childhood malaria mortality in particular.

Civil registration of deaths in most African countries is notoriously inadequate. In many rural areas, 80% or more of childhood deaths occur at home and are not reported in either hospital statistics or national vital statistics[17].

Attribution of cause of death during household surveys can be achieved only by soliciting histories from bereaved relatives on the symptoms and clinical signs observed during the fatal illness, the verbal autopsy (VA) method. This approach has been the subject of several validation studies[18], which have concluded that measurements of malaria mortality through VA are seriously compromised by low sensitivity and specificity [19, 20] Current estimates of the malaria mortality burden in Africa [21, 22] are largely based on observations made in demographic surveillance sites (DSS). The DSS have been established to record prospectively disease and deaths, to investigate epidemiological determinants of child survival, and to provide a platform on which to undertake large-scale phase III and phase IV community intervention trials [23, 24] and most DSS sites have adopted VA to attribute causes of death.

Despite the above limitations, Eline L Korenromp et al concluded that with adjustment for sensitivity and specificity, VA could give a meaningful indication of malaria mortality in children in African settings. DSS can estimate time trends in malaria mortality without VA-related bias, but their usefulness for monitoring programme impact at (sub-) country level depends critically on sample size. Combined with wider-scale survey statistics on overall mortality rates, DSS form an essential source of information to national and international malaria control programmes[25].

Much of the data that is available on socio-economic and demographic differentials in association with child mortality has been derived from mortality analyses based on all cause deaths. The few studies that highlight risk factors associated with malaria are as a result of secondary data analysis for various other secondary outcomes for studies meant for other primary end points. Hence there is need to investigate and expand on the findings for malaria cause specific risk factors.

# CHAPTER TWO: AIM AND SPECIFIC OBJECTIVES

## 2.1 Aim of the study

The general objective of the study is to identify socio-economic and demographic factors associated with mortality from childhood malaria in Navrongo DSS site in rural Ghana.

## 2.2 Specific Objectives

2.2.1 To measure the trends of childhood malaria mortality in Navrongo DSS using Verbal autopsy data, during the period of 1995-2000.

2.2.2 To determine the association between the maternal factors and childhood malaria mortality in Navrongo DSS.

2.2.3 To establish the association between the child factors and childhood malaria mortality.

2.2.4 To assess the association between childhood malaria mortality and the socio-economic factors.

## CHAPTER THREE: METHODOLOGY

### 3.1 Study Design

This study is a cross sectional analytical study using secondary analysis of longitudinal demographic surveillance system data collected during the period 1995-2000. Permission was obtained from Navrongo Health Research Centre to use the data set.

### 3.2 Study site

This study was conducted in Kassena-Nankana District in the Upper East Region of Ghana. The district stretches over an area of 1,674 $km^2$ along the Ghana-Burkina Faso border and is home to a population of about 140,000 inhabitants. The district is largely rural, with only 9.5% living in urban quarters. The population consists of two distinct ethno-linguistic groups: the *Kassena* form 49% of the district's population, while the *Nankani* constitute about 46%. The *Builsa* and migrants belonging to other ethnic groups make up the remaining 5%.

The district has a hospital, four health centres and four clinics located in selected communities. These static health delivery points are complemented by community-based service delivery in all but the eastern part of the district, which serves as an experimental control cell. As part of the Ghana Ministry of Heath policy, free health services are available to all under fives and those aged 70 years and above.

The district houses the Navrongo Health Research Center (NHRC) that amongst other research endeavors employs a demographic surveillance system to map the entire district, monitoring the population dynamics on a 90-day cycle.

### 3.3 Study Population

The study considered all children born between 1990 to 2000, who were under the age of five, who died of any cause, (but the study was in particular interested in those who died of malaria) and those who survived during the period of 1995-2000, and were residing in Navrongo DSS.

The Navrongo DSS prospectively monitors (and links observations of) these children and their attributes, and the DSS has a death-tracking system that is able to capture child deaths in a timely fashion through administration of “verbal autopsy” (VA) interview with the primary caregivers of deceased. These links allow the influence of household relationships on the risk of dying to be taken into account, and as such facilitated the link between a child who died of malaria/other cause and the mother’s demographic and socio-economic characteristics.

### 3.4 Sample Size

All the children under the age of five residing and dying of any cause in the study area and those who survived during the study period were analyzed in this study and since the cause specific deaths are few, again all the children under five who died of malaria and other causes during the 1995-2000 were considered to be eligible.

Two data sets were made available for this study. Data set 1 contained information on births that occurred between 1990 and 2000. For each birth we had corresponding information on the mother and compound level information (possessions). This data set had 61,205 observations/records.

Data set 2 contained information on deaths occurring between 1995 and 2000 to children born between 1990 and 2000. Information here was limited to basic information on the child and the final cause of death as determined from the VPM. This dataset had 4,902 observations/records.

After data editing/cleaning, we had a total of 29,535 complete records that were eligible for analysis. There were two comparison groups i.e. those who died of malaria (1,505), those who died of other causes (2,675) against those who survived (25,355), a group that was used as a base. In order to generate the age of each child born between 1990 and 2000, the variable dodd was generated, dodd=max (dod) by (birth_da). When checked, there was 19301 records that did not have the variable i.e. it was missing. This was one important variable of the analysis and all those records with missing dodd (meaning we cannot know the age of the child) were dropped. Editing the maternal age, we had 4749 records with missing maternal age; again these were dropped. Further editing of the age of the child revealed children with the age less than 0 and those above the age of 5. We deleted records with age less than 0 (75 observations) and those over 5 years (7616 observations). We further dropped 12 observations on the basis that the maternal age was less than 12 years and a further 20 on the basis that the final diagnosis was unknown.

### 3.5 Data Collection Instrument

The data for this study was collected as part of the longitudinal DSS data. This involved:

a) Initial Census: The DSS started with a baseline census of the rural district in 1993, followed by compound visits at 90-day cycles to monitor demographic events (births, deaths, and marriages, in- and out-migration and obvious pregnancies). The baseline survey included a socio-economic module, which lists compound possessions as well as the materials used in constructing the building. In the last quarter of 1995, DSS activities were extended to include Navrongo town, the only urban area in the district. To qualify as a compound member, a person should have been resident in the compound for at least three months, except for a newborn baby whose mother is already a compound member. The initial DSS covered approximately 125,000 people but with the addition of the urban area, the population has increased to over 140,000.

Therefore updated compound information was extracted for the mothers of children born between 1990 and 2000.

b) Verbal autopsies on deaths that occurred to children who were registered in the DSS were also conducted to obtain information on the circumstances leading to the death. Trained field supervisors visited each of the compounds where a death has been reported and administered the appropriate verbal autopsy questionnaire to the closest relative of the deceased. Three medical doctors coded these questionnaires independently to determine the probable cause of death. The three physicians discussed discordant diagnoses. Where consensus was not reached, the cause of death was categorized as ill defined/unknown. Records of deaths due to malaria and other causes were extracted for children under the age of five.

After merging the two data sets, a base group of children under five was identified and it comprised of those children who did not die, but were born during the same period as the children who died of other causes and those who died of malaria. The children who died of malaria and other causes had a diagnosis in their record after merging the datasets.

### 3.6 Data Analysis

The study was expected to generate data for the identification of intervention points to reduce malaria related mortality in children at the household level.

The crude malaria childhood mortality rates were estimated from verbal autopsy data and updated vital registration (births) data using the Poisson exact distribution and trends established over the period 1995-2000. The mean crude childhood malaria death rates were presented as rates per 1000 population of children under five and graphically to show the trends over the period under study. The odds ratio of dying of malaria relative to other causes were also computed and plotted to show trends over the period of study.

The dependent variable (outcome variable) is child mortality (i.e. died, which had three comparison groups; those who died of malaria, those who died of other causes and those who survived). The independent variables included (1) maternal education, (2) maternal age, (3) child's sex, (4) child's age, (5) the area of residence (6) wealth status of the family and (7) presence of bed net. Multinomial logistic regression was used to predict or model the child mortality (under-5) from independent variables and to explore relationships among the independent variables to find out which factors influence or are associated with child malaria mortality and mortality due to other causes. Selecting the variables for multivariate regression model was accomplished by including those variables that were significantly associated with malaria/other cause mortality in univariate models.

### 3.6.1 The wealth index: Living Standards Index

A straightforward and pragmatic statistical procedure called principal components analysis (PCA) has been used to determine the weights for an index of the assets variable.[26, 27, 28]. In our study, the relationship between socioeconomic status and child mortality was estimated without income or expenditure data but instead by using household asset variables. Principal components analysis provides plausible weights for an index of assets to serve as a proxy for SES or wealth. An index of living standards was created and households were categorized into five social status or poverty groups and then the relationship between these groups and childhood malaria mortality and mortality due to other causes was explored in a univariate and multivariate model.

In the context of Ghana, as is the case in other African countries, the idea of employing household characteristics as a proxy for SES to examine its relationship with mortality is not only prudent but also simple: the type of household characteristics and material possessions owned by the household are useful determinants of the health status of household members, particularly children, as well as indicators of the SES of households such as their purchasing power. Furthermore, the interest in this paper is to examine the combined effect of household characteristics (as an indicator of SES or living standards) and not the individual effect of the variables [29].

The basic idea behind information on household possessions is that households with piped water, flush toilets, a finished cement floor, roofing made from metal, using electricity for cooking, or those that possess a variety of consumer goods (ranging from a car, or a motorbike to a radio, VCR, or a truck) are more likely to achieve good health status than those without these facilities or those that rely on surface water, pit latrines, rudimentary floors, etc. [29]. These household possessions are considered as indicating the level of affordability of good health services and some are markers of the capacity for personal hygiene.

The 1995-2000 NDSS compound data for study children included information on 37 asset indicators that were grouped into two types: 1] characteristics of the household's dwelling with 13 indicators (five about sources of drinking water, six about toilet facilities, one about roofing materials, and one about wall and flooring materials); and 2] household ownership of consumer durables with 24 questions (radio, bicycle, motorcycle, motor vehicle, trucks, tractors, beds, television, sewing machine, gas/solar lamp, lanterns, coal pots/kerosene stove, gas/electric cooker, refrigerators, cattle, donkeys, sheep, goats, pigs, turkeys, chickens, guinea fowls, ducks, and ox-cart).

Figure C.4 in Appendix C presents the graph of scoring coefficients (f1) from the PCA of the household asset variables from the 1995-2000 NDSS data. Each indicator was dichotomous: higher positive scores are assigned to variables that are more likely to be associated with richer households and low or negative values are more likely to be associated with poor households. For instance, positive values are assigned to piped water inside house, iron sheets, motor vehicle, cement floor, etc. On the other hand, low or negative values are assigned to traditional pit latrine, borehole/well, etc. We sorted individuals by the asset index and established cut-off values of the population. These quintiles range from the poorest 20.31% to the least poor 18.63% and are summarized according to their classification in Table 4.1.1 in the result section. The expectation is that households in the least poor quintile should have the highest mean values of those variables that scored high on the asset index and this should progressively decrease with the movement from the topmost quintile to the poorest quintile.

**3.6.2 Residence variable:**

Apart from the compound identification number and the unique permanent ID, each study child had information on locality of residence, which was identified by a code. In the dataset provided, there were 130 localities coded. Out of this, five localities represented the urban setting and the rest represented the rural part of the district. The dummy variable was therefore derived, such that five localities represented the urban area (1) and the rest represented the rural area (0).

### 3.6.3 Maternal education level variable:

The education level of the mothers was determined on the basis of formal education and years spent in school. The time in years spent in school ranged from 0 to 22 years. Zero represents those who have never been to school. The current system of school in Ghana is such that you have lower primary for three years, upper primary for three years, junior secondary school for three years and then a further three years of senior secondary school. Thereafter, one can proceed to college or university. In the dataset provided, when we categorized the maternal education level into the above six categories, those with higher education from senior secondary to college/university were very few and hence the need to consider broad categories; those mothers without education and those with some education.

### 3.6.4 Bed net ownership variable:

The dataset had a variable on bed nets and this was in response to the question on ownership. The response was recorded as the number of bed nets the family owned i.e. per compound, and ranged from 0 to 40. In a full dataset, 46% of the study children came from compounds that had no bed nets (27,377/59345). About 90% of the compounds (53,228/59345) that had nets, had less or equal to four nets per compound and further analysis showed only 5% (2975/59345) had more than six nets per compound. There are several households per compound ranging up to 14, and being compound based data, it is difficult to indicate how many bed nets a household therefore possessed and whether or not under five children had access to those nets. We therefore did not take into consideration how many nets a compound owned, but just looked at ownership with a dummy variable created to represent those study children coming from families who owned bed net (1) and those with out (0).

### 3.6.5 Maternal age group variable:

The maternal age of the mothers of study children was determined on the basis of the age of the mother at birth of the study child. It was computed by subtracting the mother's date of birth from the birth date of the child. The age ranged from 12.6 to 54.5 years. The initial plan was to categorize the age into five groups such that the youngest mother up to age 19, represented category one, followed by the 20 –29 year olds, then the 30-39 year olds, 40-49 year olds and lastly the 50-59 year olds. But it was observed that when we categorize maternal age this way, there were very few mothers in the last two older age groups. Therefore, we reduced it to two categories; those mothers aged less than 30years (younger mothers) and those older than 30 (older mothers). However, both maternal age categories were used in the analysis.

### 3.6.6 Age group of the children variable:

The age groups for study children were determined on the basis of how old the child was at the time of death. It was computed by subtracting the child's date of birth from the date of death of the child. Another variable (dodd) was created to represent a date of death for those children who did not die (survived), and therefore allowed us to calculate the age for those who survived at the time the others died. The variable dodd was a censoring date for those who did not die. The age was worked out in years and ranged from 0 to 4.99 years, and we had two broad categories; for those children aged zero to 0.999 as infants and those aged 1.000 years to 4.999 years as older children. For univariate and multivariate analysis, we considered three groups, i.e. infants representing children who were breastfeeding, 1 year to less than two year olds representing children in the weaning period, and those children two years and older representing the group of children sharing the family food.

### 3.6.7 Sex of the child variable:

The dataset had a string variable that represented the gender; either the study child was "Male" or "Female". A dummy variable, sex was created to replace gender, with the sex of the child being male (0) or female (1).

## 3.7 Ethical Considerations

The protocol for this study was submitted for review and was approved by the University of the Witwatersraand Committee for Research on Human Subjects (Medical) and the Institutional Review Board of Navrongo Health Research Center. The Director and the leader of the NDSS unit at Navrongo Health Research Centre, also gave approval for access to data for the purposes of this study as was agreed with the University of the Witwatersrand School of Public Health to facilitate my fulfillment of the MSc Population Based Field Epidemiology course.

Community consent was obtained from the community at the commencement of the DSS, and the community and its leaders have been kept informed and participate through regular community feedback meetings. Proper community entry procedures are carried out prior to commencement of fieldwork every cycle. Further, identifiers were removed from the datasets that were made available for the analysis.

The study involved secondary data analysis and therefore no direct contact with participants and did not have potential risks of injury.

The main benefit from this study is the identification of factors that can be modified through health education and promotion, to further reduce the childhood malaria mortality in addition to the current efforts of ITNs and Case management with antimalarial.

Confidentiality: Each reference record was assigned a unique study number and linked to the DSS database. Permission was sought, and data extracted by the responsible Data manager. I was made to sign a confidentiality agreement in order to guarantee the security of information pertaining to individual participants and data analysis was done in such a way that no individual could be identified.

# CHAPTER FOUR: RESULTS

## 4.1. UNIVARIATE ANALYSIS

Table 4.1.1 below, presents the percentage distribution of study participants according to their selected background characteristics. In this study, a total of 29,535 study participants were included. The largest proportion of the study children (94.3%) were from the rural area of the district. Reviewing study children by maternal education, 83.4% of them were born of mothers with no education (see also figure C.5). Most of the study children were borne of younger mothers i.e. mothers less than 30 years old (58.5%). About 46.4% of study children were borne of mothers in the age group 20-29 (figure C.4, appendix C). The maternal age had a mean and standard deviation of 28.8 and 7.5 respectively. The study children were almost equally divided among males (49.8%) and females (50.2%). This is also demonstrated in figure D.6 below.

The age distribution showed that most study children (63.9%) were in the older group (1-5 years old) compared to infants. The mean and standard deviation of the age of study children was 1.8 and 1.4 respectively.

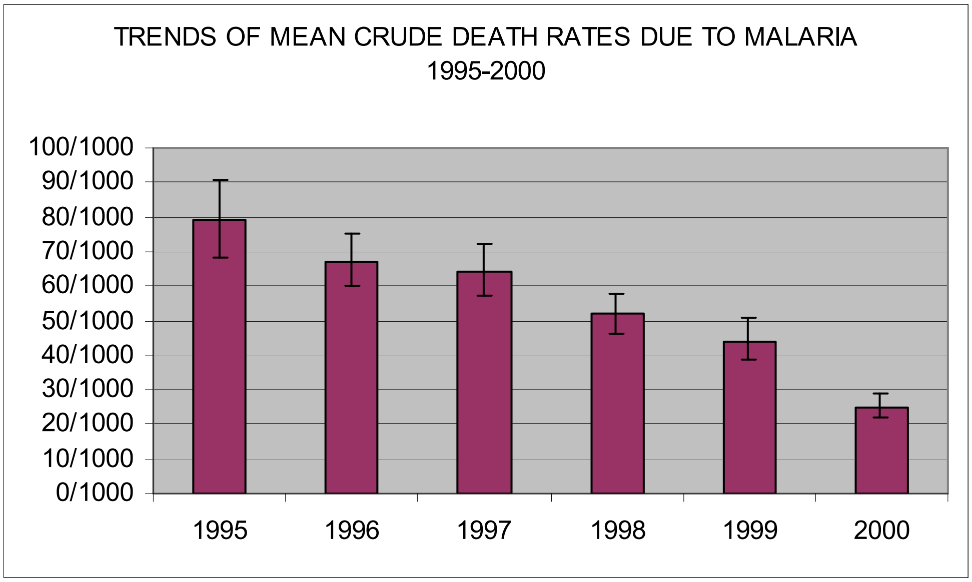
There were more study children (54.8%) who came from families (compounds) that possessed a bed net. Further review of study children by wealth index of the family, showed that those classified poorest were 20.3%, followed by poorer (20.7%), poor (20.2%), less poor (20.2%) and the least poor (18.6%). Most of the children came from poor families as graphically demonstrated in figure C.4 (Appendix C).

**Table 4.1.1. Background characteristics of study participants**

| Background characteristic | Number | Percent |
|---|---|---|
| **Sex of child** | | |
| Male | 14,714 | 49.8 |
| Female | 14,821 | 50.2 |
| **Age group of children** (Mean=1.78, std. dev. =1.35) | | |
| Infants | 10,646 | 36.1 |
| 1-<2yrs | 7,737 | 26.2 |
| ≥2yrs | 11,152 | 37.7 |
| **Age group of mothers** (Mean=28.78, std. dev.=7.47) | | |
| <30 | 17,287 | 58.5 |
| >30 | 12,248 | 41.5 |
| **Wealth index (quintiles) of family** | | |
| Poorest | 5,832 | 20.3 |
| Poorer | 5,946 | 20.7 |
| Poor | 5,789 | 20.2 |
| Less poor | 5,795 | 20.2 |
| Least poor | 5,348 | 18.6 |
| **Residence** | | |
| Urban | 1,697 | 5.7 |
| Rural | 27,838 | 94.3 |
| **Bed nets ownership** | | |
| Family with | 16,174 | 54.8 |
| Family without | 13,361 | 45.2 |
| **Education level of mother** | | |
| No education | 24,631 | 83.4 |
| Some education | 4,904 | 16.6 |

There were 1505 deaths due to malaria out of the 4,180 total deaths due to all causes (36.0%) that occurred in the study population of 29,535 children under five years, over the study period (1995-2000). A break down of the malaria deaths into each year under study and the total population of children under five years old in those particular years was done to allow for plotting of malaria mortality trends over the years.

**Figure 4.1.1.**

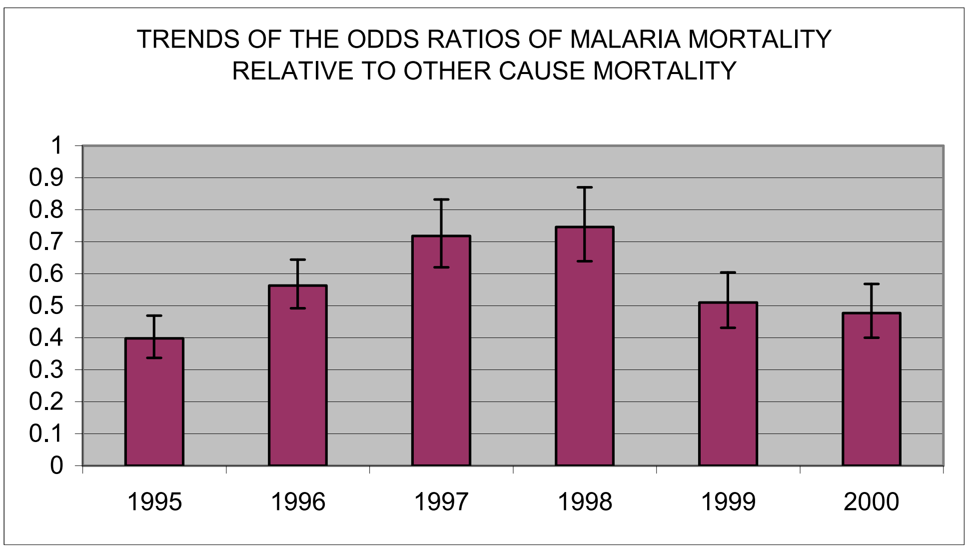



The crude death rates plotted in figure 4.1.1 above were obtained by computing 95% confidence intervals with the number of exposure as the total population of children under five in each year, and the number of events as malaria deaths in each year among the under fives, using Poisson exact distribution (appendix E). There is a decrease in the mean rate of deaths due to malaria from 1995 to 2000, though the decrease was slight during the period 1996 to 1997.

The malaria mortality trends were also further analyzed in relation to mortality due to other causes (appendix F). Here a trend was observed as shown in figure 4.1.2 below with the odds of dying of malaria in relation to other causes increasing from 1996 and decreasing after 1998.

Overall, a test for trend showed that there was no trend ($X^2$=1.26 P=0.262), maybe because of the fact that there was an initial increase and then a decrease in the odds of mortality from malaria in relation to other causes. However, if you restrict the observations to 1997 onwards, the observed decrease in the odds of malaria mortality in relation to mortality due to other causes has a statistically significant trend ($X^2$=23.22 P<0.0001)

**Figure 4.1.2.**




The odds of malaria mortality in relation to dying of other causes increased between 1995 and 1996 and were statistically significant as there was no overlapping of confidence intervals. However, the increase in the odds of malaria mortality between 1996 and 1997 were not significant with confidence intervals overlapping, the same for the observed increase between 1997 and 1998. The decrease observed between 1998 and 1999 was statistically significant, as the confidence intervals do not overlap. However, a further decrease observed between 1999 and 2000 was not significant with overlap between the confidence intervals.

Figure 4.1.3 presents trends for malaria mortality in comparison to all cause mortality. The all cause mortality decreased from 1996 to 1998 and increased slightly in 1999, but declined sharply in 2000. Deaths due to Malaria however did not show any increase, and in fact continued to show a steady decrease particularly after 1998.

**Figure 4.1.3.**

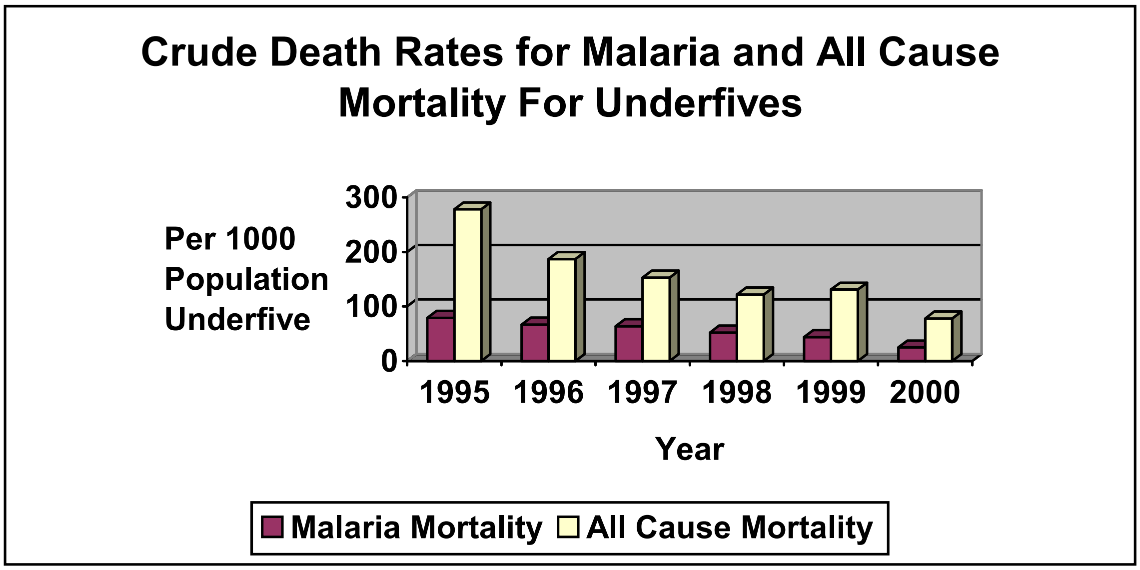



Table 4.1.2 presents study children in the three comparison groups of those who died of malaria, those who died of other causes and those who survived, by sex and age group of the child, age of the mother, wealth index of the family, residence, bed net and maternal education level.

At 5% level of significance, the results show that mortality was significantly associated with the sex of the child, age group of the child, age group of the mother, wealth index of the family, residence and the educational level of the mother.

The gender distribution of the study children was such that, there were similar proportions between males and females among those who died of malaria and those who survived (about 50.0%). But there was a slight difference in the proportion of males (52.1%) compared to females (47.9%) for those who died of other causes. Therefore there was slightly more males dying of other causes (52.1%) than malaria or the proportion of those surviving. The proportion of females surviving (50.4%) was equal to that of male surviving but the proportions of female dying of malaria (49.9%) and of female dying from other causes (47.9%) were less than their counterparts; there could therefore be a likelihood of slightly more deaths occurring in male children than their female counterparts.

In terms of age distribution for study children, the proportion of infants (36.7%) was high among those who survived followed by those who died of other causes (33.6%) then those who died of malaria (29.2%). The proportion of those children one year but less than two years was similar for those who died of malaria (31.4%) and other causes (29.7%), but it was less for those surviving (25.5%). For children aged two years or older, the proportion of those dying of malaria was more (39.5%) compared with those who survived (37.8%) and those dying of other causes (36.7%).

The proportion of young mothers (<30 years old) was more among children who survived (59.3%) compared to those children who died of other causes (54.6%) and those who died of malaria (52.5%). There was however, a high proportion of older mothers

(>30years old) among those children who died of malaria (47.5%) compared to those who died of other causes (45.4%) and those who survived (40.7%).

In terms of wealth index for families of study children, there was slightly high proportion of children dying of other causes (23.1%) compared to those who died of malaria (21.6%) and those who survived (19.9%) among the poorest category. It was still observed that the proportion remained high in the poorer category for children dying of other causes (23.4%) compared to those children dying of malaria (22.5%) and those who survived (20.3%). In the poor category, the proportion of those dying of malaria was high (22.3%) compared to those surviving and those dying of other causes who had similar proportions (≈20%). There was not much difference in proportions among the three comparison groups in the less poor category. There was however a notable difference in the least poor category with children who survived having a high proportion (19.5%) compared to those who died of malaria (14.4%) and those who died of other causes (13.2%).

When comparing proportions within each group, there is a decrease in the proportions as one moved from the poorest category of wealth to the least poor category for the two comparison groups of those who died of malaria and other causes. For those who died of malaria, the poorest category of wealth is 21.6% compared to 14.4% for the least poor in the same group. Similarly those dying of other causes, the proportion for the poorest is about 23.1% compared to the least poor, which is 13.2% in the same group. However, there is an opposite trend in the group that survived, with the proportions remaining almost the same as one moved from the least poor to the poorest category of wealth.

Across all the three groups, most study children came from the rural area of the NDSS. There were similar proportions (≈96.0%) among children dying of other causes and malaria, which were higher than the proportion of children surviving (93.9%) but living in the rural part of the NDSS. The proportion of children surviving was high (6.1%) in urban area of the DSS compared to that dying of malaria (3.3%) and other causes (3.7%). The proportions of study children coming from a compound possessing a bed net were similar among all three-comparison groups (≈54.0%). Equally, the proportions of study children coming from compounds without a bed net were also similar among all three-comparison groups (≈46.0%).

The proportions of study children born of mothers with some education were lower for those who died of malaria (12.6%) and those who died of other causes (13.1%) compared to the proportion of children born of mothers with some education who survived (17.2%). Inversely, the proportions of mothers with no education was high for children who died of malaria and those who died of other causes (≈87.0% in each case) compared to those mothers of children who survived (82.8%).

**Table 4.1.2. Background characteristics of three groups**

| Background characteristics | Those who died of malaria ("cases") N (%) | Those who died of other causes N (%) | Those who survived ("comparisons") N (%) | p-value |
|---|---|---|---|---|
| **Sex of children** | | | | |
| Males | 754 (50.1) | 1,394 (52.1) | 12,566 (49.6) | 0.042 |
| Females | 751 (49.9) | 1,281 (47.9) | 12,789 (50.4) | |
| **Age group of children** (Mean=1.78, std. dev. =1.35) | | | | |
| Infants | 439 (29.2) | 900 (33.6) | 9,307 (36.7) | <0.0001 |
| 1-<2yrs | 472(31.4) | 794(29.7) | 6,471(25.5) | |
| ≥2yrs | 594(39.5) | 981(36.7) | 9,577(37.8) | |
| **Age group of mothers** (Mean=28.78, std. dev.=7.47) | | | | |
| <30 | 790 (52.5) | 1,461 (54.6) | 15,036 (59.3) | <0.0001 |
| >30 | 715 (47.5) | 1,214 (45.4) | 10,319 (40.7) | |
| **Wealth index (quintiles) of family** | | | | |
| Poorest | 311 (21.6) | 602 (23.1) | 4,919 (19.9) | <0.0001 |
| Poorer | 324 (22.5) | 610 (23.4) | 5,012 (20.3) | |
| Poor | 322 (22.3) | 532 (20.4) | 4,935 (20.0) | |
| Less poor | 277 (19.2) | 520 (19.9) | 4,998 (20.3) | |
| Least poor | 208 (14.4) | 345 (13.2) | 4,795 (19.5) | |
| **Residence** | | | | |
| Urban | 50 (3.3) | 100 (3.7) | 1,547 (6.1) | <0.0001 |
| Rural | 1,455 (96.7) | 2,575 (96.3) | 23,808 (93.9) | |
| **Bed nets** | | | | |
| Family with | 804 (53.4) | 1,441 (53.9) | 13,929 (54.9) | 0.323 |
| Family without | 701 (46.6) | 1,234 (46.1) | 11,426 (45.1) | |
| **Education level** | | | | |
| No education | 1,316 (87.4) | 2,325 (86.9) | 20,990 (82.8) | <0.0001 |
| Some educ | 189 (12.6) | 350 (13.1) | 4,365 (17.2) | |

Table 4.1.3 presents unadjusted relative risk ratio with its 95% confidence intervals that were obtained from univariate multinomial logistic regression models by considering the variable which specify whether the child died of malaria or other causes or survived as the outcome variable with the survived group as base. Sex of the child, age group of the child, age group of the mother, wealth index of the family, residence, bed nets and mother's education level were used as the explanatory variables in the univariate multinomial logistic regression model.

At 5% level of significance, the results of the univariate multinomial logistic regression showed that the study child's family possessing a bed net was not statistically significant for both the group that died of malaria and those that died of other causes in relation to those that survived. Therefore, the variable bed nets were not considered in the multivariate multinomial logistic regression model as the explanatory variable.

The sex of the child was not statistically significant for those that died of malaria, but was statistically significant for those who died of other causes.

On the wealth index, in fact we observed a clear biological gradient, with the risk of an outcome (death either due to malaria or other causes) increasing with an increase in the dose of the exposure (least poor to poorest). Therefore there is a demonstration of the dose response relationship

**Table 4.1.3. Univariate Analysis With Unadjusted P-Values**

| Background characteristic | Died of Malaria RR (95%CI) p-value | Died of other causes RR (95%CI) p-value |
|---|---|---|
| **Sex of child** | | |
| Male | 1 | 1 |
| Female | 0.98 (0.88-1.09) 0.684 | 0.90 (0.83-0.98) 0.012 |
| **Age group of children** (Mean=1.8, std. dev. =1.4) | | |
| Infants | 1 | 1 |
| 1-<2yrs | 1.55 (1.35-1.77) <0.0001 | 1.27 (1.15-1.40) <0.0001 |
| ≥2yrs | 1.31 (1.16-1.49) <0.0001 | 1.06 (0.96-1.16) 0.234 |
| **Age group of mothers** | | |
| <30 | 1 | 1 |
| >30 | 1.32 (1.19-1.46) <0.0001 | 1.21 (1.12-1.31) <0.0001 |
| **Wealth index (quintiles) of family** | | |
| Poorest | 1 | 1 |
| Poorer | 1.02 (0.87-1.20) 0.786 | 0.99 (0.88-1.12) 0.928 |
| Poor | 1.03 (0.88-1.21) 0.701 | 0.88 (0.78-0.99) 0.043 |
| Less poor | 0.88 (0.74-1.04) 0.121 | 0.85 (0.75-0.96) 0.010 |
| *Least poor* | 0.69 (0.57-0.82) <0.0001 | 0.59 (0.51-0.68) <0.0001 |
| **Residence** | | |
| *Urban* | 0.53 (0.40-0.70) <0.0001 | 0.60 (0.49-0.73) <0.0001 |
| Rural | 1 | 1 |
| **Bed net ownership** | | |
| *Family with* | 0.94 (0.85-1.04) 0.252 | 0.96 (0.88-1.04) 0.292 |
| Family without | 1 | 1 |
| **Education level of mother** | | |
| No education | 1 | 1 |
| Some education | 0.69 (0.59-0.80) <0.0001 | 0.72 (0.64-0.81) <0.0001 |

## 4.2 Multivariate Analysis

Table 4.2.4 presents adjusted relative risk ratios with 95% confidence intervals which were obtained from multivariate multinomial logistic regression model 1 by considering the variable which specify whether the child died of malaria or other causes or survived as the outcome variable with the survived group as the base. Sex of the child, age group of the child, age group of the mother, wealth index of the family and mother's education level were all significantly associated with the outcome variable in the multivariate multinomial logistic regression model 1.

Based on the adjusted relative risk ratios and p-values obtained through multivariate multinomial logistic regression, there was no statistical association between malaria mortality and sex of the child, the risk was similar for both males and females. But for those study children who died of other causes, there was a risk reduction (RRR 0.91, P=0.017) if one was female in relation to males.

Age group of the child was associated with malaria mortality. The first category of older children (1-<2 years old) had a 1.56 times risk of dying of malaria and the second category of age group (≥2 years old) having a 1.29 times risk of dying relative to infants (P<0.0001). Age group of the child was also associated with mortality due to other causes, and this was 1.26 times higher in the age category of 1-<2 year olds, but there was no difference with the risk in infants for those older or equal to two years (P=0.202). Study children borne of older mothers were 1.29 times (P<0.0001) likely to die from malaria than those born of young mothers. Similarly, those born of older mothers were

1.16 times (P<0.0001) more likely to die from other causes than those born of younger mothers. Maternal education was associated with mortality. Study children borne of mothers with some education were at reduced risk; with those that died of malaria having a relative risk ratio of 0.82 (P=0.019) and those who died of other causes having a relative risk ratio of 0.87 (P=0.023) compared to those children born of mothers without education.

The wealth index of the family was associated with mortality, with study children whose families were in the least poor category having reduced risk of dying from malaria (RRR 0.76, P=0.003) compared to those who were from the poorest category. The wealth index was also protective for those study children whose families were in the two categories of less poor and least poor for the group that died of other causes. It offered a reduced risk (RRR 0.87, P=0.032 and RRR 0.62, P<0.0001 respectively) compared to those who were in the poorest category.

This first multivariate model was based on the fact that the bed net variable was not included since it was not statistically significant in the univariate model. Then the model with both the residence and wealth index included was showing no statistical significance among those who died of other causes. Again, it was showing reduced levels of significance for both the relative risk ratio and the P-value for those who died of malaria (Appendix A). A check for interaction revealed significant interaction between wealth index and residence.

A further cross tabulation between the wealth index variable and residence variable (table 4.2.5, below) showed that the majority of people living in rural (85.5%) were poor and majority of people living in urban (84.9%) were well off (least poor). Therefore the relationship of the residence with mortality is explained by the wealth index variable. Therefore in final model (model 1), the residence variable was also not included.

**Table 4.2.4. Multivariate Analysis With Adjusted P-Values (model 1)**

| Background characteristic | Died of Malaria<br>RR (95%CI) p-value | Died of other causes<br>RR (95%CI) p-value |
|---|---|---|
| **Sex of children** | | |
| Males | 1 | 1 |
| Females | 0.97 (0.88-1.08) 0.620 | 0.91 (0.84-0.98) 0.017 |
| **Age group of children**<br>(Mean=1.78, std. dev. =1.35) | | |
| Infants | 1 | 1 |
| 1-<2yrs old | 1.56 (1.36-1.78) <0.0001 | 1.26 (1.14-1.40) <0.0001 |
| ≥2yrs old | 1.29 (1.14-1.47) <0.0001 | 1.06 (0.97-1.17) 0.202 |
| **Age group of mothers** | | |
| <30 | 1 | 1 |
| >30 | 1.29 (1.16-1.43) <0.0001 | 1.16 (1.07-1.26) <0.0001 |
| **Wealth index (quintiles) of family** | | |
| Poorest | 1 | 1 |
| Poorer | 1.04 (0.89-1.22) 0.617 | 1.01 (0.89-1.13) 0.927 |
| Poor | 1.06 (0.90-1.24) 0.484 | 0.89 (0.79-1.01) 0.076 |
| Less poor | 0.91 (0.77-1.08) 0.285 | 0.87 (0.77-0.99) 0.032 |
| *Least poor* | 0.76 (0.63-0.91) 0.003 | 0.62 (0.54-0.73) <0.0001 |
| **Education level** | | |
| No education | 1 | 1 |
| Some education | 0.82 (0.69-0.97) 0.019 | 0.87 (0.76-0.98) 0.023 |

**Table 4.2.5. Cross tabulation of wealth index by residence**

| Quintiles of wealth index | Residence | |
|---|---|---|
| | Rural | Urban |
| 1 | 5,827 (21.57%) | 5 (0.29%) |
| 2 | 5,915 (21.90%) | 31 (1.83%) |
| 3 | 5,688 (21.06%) | 101 (5.95%) |
| 4 | 5,676 (21.01%) | 119 (7.01%) |
| 5 | 3,907 (14.46%) | 1441 (84.91%) |

Table 4.2.6 presents adjusted relative risk ratios with 95% confidence intervals which were obtained from multivariate multinomial logistic regression model 2 by considering the variable which specify whether the child died of malaria or other causes as the outcome variable with the survived group as base. Sex of the child, age group of the child, age group of the mother, residence of the family and mother's education level were all significantly associated with the outcome variable in the multivariate multinomial logistic regression model 2.

The results for all the explanatory variables were similar to those in table 4.2.4 except this model did not include the wealth index variable. This model however included the residence variable which was associated with mortality, with study children whose families were in the urban area of the DSS having reduced risk of dying from malaria (RRR 0.61, P=0.001) relative to those who lived in the rural area of the district. Similarly, the residence was also protective against mortality from other causes. It offered a reduced risk (RRR 0.79 P<0.0001) relative to those study children whose families lived in the rural area. However, for reasons explained earlier, we considered model 1 as the final model, the model 2 with residence variable is not the best to explain the relationships since relationship with mortality is explained better by the wealth index.

**Table 4.2.6. Multivariate Analysis With Adjusted P-Values (Model 2)**

| Background characteristic | Died of Malaria<br>RR (95%CI) p-value | Died of other causes<br>RR (95%CI) p-value |
|---|---|---|
| **Sex of children** | | |
| Males | 1 | 1 |
| Females | 0.98 (0.88-1.09) 0.674 | 0.90 (0.83-0.98) 0.011 |
| **Age group of children** (Mean=1.78, std. dev. =1.35) | | |
| Infants | 1 | 1 |
| 1-<2 yrs old | 1.54 (1.35-1.76) <0.0001 | 1.26 (1.14-1.40) <0.0001 |
| ≥2 years old | 1.30 (1.15-1.48) <0.0001 | 1.05 (0.95-1.15) 0.317 |
| **Age group of mothers** | | |
| <30 | 1 | 1 |
| >30 | 1.28 (1.15-1.42) <0.0001 | 1.17 (1.08-1.27) <0.0001 |
| **Residence** | | |
| *Urban* | 0.61 (0.46-0.82) 0.001 | 0.67 (0.55-0.83) <0.0001 |
| Rural | 1 | 1 |
| **Education level** | | |
| No education | 1 | 1 |
| Some education | 0.79 (0.67-0.93) 0.004 | 0.79 (0.70-0.90) <0.0001 |

## CHAPTER FIVE: DISCUSSION

### 5.1 Demographic and socioeconomic factors associated with childhood malaria mortality

Malaria was responsible for 36.0% of childhood deaths in the DSS during the period under study (1995-2000). This is consistent with the WHO-AFRO routine Health Information System data Averages 1998-2001 report that gave a profile for western African countries that included Ghana and put the deaths due to malaria at 30%[6]. The finding was also comparable to observations made in other African countries south of the equator, Salum FM et al in a pilot study in rural Tanzania found 36% of child mortality (1-4 year olds) attributed to Malaria[11].

In this study, both univariate and multivariate analysis results did not show any evidence of association between childhood malaria mortality and sex/gender. This is similar to observations in other studies, where among children, no consistent sex difference was detected in either malaria-related mortality or anemia-related mortality[30]. A study in Myanmar (Tin-Oo *et al.*, 2001) provides further evidence of an insignificant sex difference in malaria incidence[31].

Further, in a study looking at all cause childhood mortality, Jean-Francois et al, observed that over the study period, infant mortality among boys was larger than in girls (90 versus 75/1000 births, RR = 1.19 [95% CI: 1.07, 1.33], $P = 0.001$). This effect was significant during the neonatal period (38 versus 28/1000 lbirths, RR = 1.36 [95% CI: 1.14, 1.63], $P < 0.001$) and the post-neonatal period (89 versus 75/1000 children alive at day-29, RR =

1.18 [95% CI: 1.06, 1.32], $P < 0.01$) [16]. No effect of gender in the other age groups/periods reached statistical significance.

The age group of the child was associated with childhood malaria mortality. Children in the older age group (1-5 years old) were 1.4 times more likely to die of malaria compared to infants. Further refinement of age groups for children showed that the risk for childhood malaria mortality was more for the children 1 year old to less than two years (RRR=1.56, P<0.0001) but was slightly less (RRR=1.29, P<0.0001) for children in the older age (≥2 years old). There was limited reference on malaria specific mortality in literature review. This is a great challenge that may require further investigations. However, reference to the Ghana Demographic and Health Survey 2003 report, show more infants sleeping under the bed nets than older children (about 20% versus 13% respectively). May be this could explain the results observed in part.

The age group of the mother was associated with childhood malaria mortality. Children borne of older mothers (>30 years old) were 1.3 times more likely to die of malaria than those borne of younger mothers. In a study in Burkina Faso, Becher et al showed that for all cause mortality in children, the age of the mother has a significant impact independent of the order of birth. Both low age (<18 years) and high age of mother (>36 years) was associated with an increased risk (RR 1.37, 95 % CI 1.13-1.65 and RR 1.13, 95 % CI 0.94-1.37 respectively) [15].

In further analysis of childhood malaria mortality and maternal age, with refined categories for age group (appendix B, table B.8), it was observed that children born of mothers between the age 20 to 29 years were at a lesser risk (RRR=0.94) compared with those born of mothers younger than 20 though this was not statistically significant. However, the risk for mortality due to malaria increased for children born of mothers older than 30, with those in the age group 30 to 39 having a risk of 1.18 times (P=0.078) and those older than 40 with a risk of 1.41 (P=0.004). This finding was consistent with other studies for all cause mortality and it was also interesting to see that this comparable result was from a DSS.

This study showed that the wealth index of the family was associated with childhood malaria mortality. Children in the least poor category had reduced/less risk of dying of malaria (31% reduction in univariate and 24% reduction in multivariate model) than those children borne of families in the poorest category. There was a clear demonstration of the dose response relationship between wealth index and childhood malaria mortality. All cause child mortality rates are known to be higher in poorer households and malaria is responsible for a substantial proportion of these deaths. In a DSS in rural areas of the United Republic of Tanzania, the under-5 mortality following acute fever (much of which would be expected to be due to Malaria) was 39% higher in the poorest socio-economic group than in the richest[14]. Also, recent evidence from another Tanzanian DSS site (de Savigny *et al.*, 2002) indicates that the poorest infants and children under five-years of age had higher risks of death than those in the least-poor socio-economic quintiles[32].

Again, Bloland P et al in a cohort study in rural Malawi, found the combination of low education and low socio-economic status of the mother (hazard ratio=2.6) to be predominant risk factors for mortality occurring during the second year[13].

The evidence with regard to vulnerability to the consequences of malaria by groups of lower SES is more consistent. Studies examining SES using assets, education, and occupation all yield data that suggest an inverse relationship between the severity of malaria's effects and SES [33,34,35]. The finding from our study is therefore consistent with the observation from the other studies.

The residence of the family was associated with childhood malaria mortality. Study children who were residing in the urban area were at reduced/less risk of dying of malaria (47% reduction in univariate and 39% reduction in multivariate model) than those who were residing in rural parts of the DSS. A rural or urban categorization is sometimes used as a proxy for SES, based on the assumption that people in rural areas tend to be poorer than those in urban areas. This association observed in our study is therefore important and further reflects consistency of the findings about the association of wealth index and residence with malaria mortality.

Rural locations can be associated with increased malaria risk for both epidemiological and socio-economic reasons. Similarly, urban residence can be accompanied by potentially protective socio-economic factors against malaria risk such as education and income [36].

A number of recent studies have used urban and rural variables in their analyses of risk factors. In Malawi, Holtz et al. examined urban location, among other potentially socio-economically relevant variables such as the education of caregivers and housing construction materials, to examine determinants of ITN use, anemia and parasitemia. The results revealed rural residence as the highest risk factor for parasitemia in children under five years of age, even after controlling for bed net use[37].

Finally, this study showed that the maternal education level was associated with childhood malaria mortality. Study children born of mothers with some education had reduced/less risk of dying of malaria (about 30% reduction in univariate and 20% reduction in multivariate model) than those children borne of mothers without any education. Bloland P et al in a cohort study in rural Malawi, found the combination of low education and low socio-economic status of the mother (hazard ratio=2.6) to be predominant risk factors for mortality occurring during the second year[13]. This is even more important going by the fact that in this study we made the observation that older children were at much higher risk than infants.

SES and educational attainment are intricately linked since those who are well educated are likely to achieve higher SES and those of higher SES are likely to be better educated
It is also important therefore to bear this relationship in mind. The education status of mothers is one of the strongest correlates of infant and child mortality because education provides women with decision-making power, making them more aware of their

children's welfare, and increasing their knowledge about childhood diseases and their ability to understand illness and provide timely treatment[38].

In a malaria related study in Zambia, knowledge of malaria was found to be positively associated with level of education [39]. Further to emphasize on the importance of maternal education, specific knowledge on the cause, prevention and treatment of malaria were found to be positively related to net ownership in Uganda [40].

The finding from our study is therefore consistent with the observation from the other studies, in as much as these were for all cause mortality.

### 5.2 Demographic and socioeconomic factors associated with all cause childhood mortality

This study showed evidence of association between other cause childhood mortality and sex/gender. There is a risk reduction of about 10% if one was female to die of other cause mortality. No effect of gender in the other age groups/periods reached statistical significance. Our finding was also consistent with the observations made from the national survey reflecting a generally higher childhood mortality rates for males than females[41].

The age group of the child was associated with other cause childhood mortality. Children in the older age group (1-5 years old) were 1.14 times more likely to die of other causes compared to infants. Further refinement of age groups for children showed that the risk for childhood all cause mortality was more for the children 1 year old to less than two years (RRR=1.26, P<0.0001) but was slightly less (RRR=1.06, P=0.202) for children in the older age (≥2 years old).

The age group of the mother was associated with other cause childhood mortality. Children borne of older mothers (>30 years old) were 1.16 times more likely to die of other causes than those borne of younger mothers. In a study in DSS site in Burkina Faso, Becher et al showed that for all cause mortality in children, the age of the mother has a significant impact independent of the order of birth. Both low age (<18 years) and high age of mother (> 36 years) was associated with an increased risk (RR 1.37, 95 % CI 1.13-1.65 and RR 1.13, 95 % CI 0.94-1.37 respectively) [15]. In our study, further analysis of childhood mortality due to other causes and maternal age, with refined categories for age group (appendix B, table B.8), it was observed that children born of mothers between the age 20 to 29 years were at a reduced risk or protected (RRR=0.69, P<0.0001) compared with those born of mothers younger than 20 and this was highly statistically significant. The same observation was made for those children born of mothers aged between 30 to 39 years old; they also had a reduced risk, or were protected (RRR=0.84, P=0.009). However, the risk for mortality due to other causes for children born of mothers in the age group 40-49 and 50-59 was not different from those in the age group younger than 20 (RRR=1.02, P=0.791 and RRR=1.34, P=0.548 respectively). This finding was therefore consistent with our finding and it is also interesting to see that this comparable result was from a DSS. The national survey also had comparable findings; births to young mothers (<20years) and older mothers (>35 years) experienced an elevated risk of mortality[41].

This study showed that the wealth index of the family was associated with other cause childhood mortality. Children in the least poor category had reduced/less risk of dying of other causes (41% reduction in univariate and 38% reduction in multivariate model) than those children borne of families in the poorest category. All cause child mortality rates are known to be higher in poorer households. In a DSS in rural areas of the United Republic of Tanzania, the under-5 mortality following acute fever (much of which would be expected to be due to Malaria) was 39% higher in the poorest socio-economic group than in the richest[14]. Also, recent evidence from another Tanzanian DSS site indicates that the poorest infants and children under five-years of age had higher risks of death than those in the least-poor socio-economic quintiles[32].

Again, Bloland P et al in a cohort study in rural Malawi, found the combination of low education and low socio-economic status of the mother (hazard ratio=2.6) to be predominant risk factors for mortality occurring during the second year[13].

The finding from our study is therefore consistent with the observation from the other studies for all cause mortality and also with the national survey during the same period. The children in the highest quintile of wealth index exhibited the lowest mortality rate for all categories of mortality[41].

The residence of the family was associated with other cause childhood mortality. Study children who were residing in urban areas were at reduced/less risk of dying of other causes (40% reduction in univariate and 33% reduction in multivariate model) than those who were residing in rural parts of the DSS. This result is consistent with the national survey findings were mortality levels in rural areas were considerably consistently higher than in urban areas[41].

Finally, this study showed that the maternal education level was associated with other cause childhood mortality. The mother's education is inversely related to a child's risk of dying. Study children born of mothers with some education had reduced/less risk of dying of other causes (about 28% in univariate and 13% in multivariate model) than those children borne of mothers without any education. The same observation was made at national level over the same period, with under five mortality among mothers with no education noticeably higher than among mothers with some education[41]. Bloland P et al in a cohort study in rural Malawi, found the combination of low education and low socio-economic status of the mother (hazard ratio=2.6) to be predominate risk factors for mortality occurring during the second year[13]. SES and educational attainment are intricately linked since those who are well educated are likely to achieve higher SES and those of higher SES are likely to be better educated

It is also important therefore to bear this relationship in mind. The education status of mothers is one of the strongest correlates of infant and child mortality because education provides women with decision-making power, making them more aware of their children's welfare, and increasing their knowledge about childhood diseases and their ability to understand illness and provide timely treatment[38].

The finding from our study is therefore consistent with the observation from the other studies for all cause mortality.

### 5.3 Comment on Findings for Malaria Mortality and Other Cause Mortality

Interestingly, the same factors observed to be associated with childhood malaria mortality were also associated with deaths due to other causes, but with varying degrees of association. Whereas the sex was not associated with malaria deaths, being female offered a lower risk of dying from other causes (RRR 0.9, 95%CI 0.84-0.98 P=0.01). It was observed that children in the older age group (1-5 years) were at higher risk of dying from malaria (RRR 1.4) and other causes (RRR 1.14) compared to infants. Those born of older mothers had a higher risk of dying of malaria (RRR 1.3) and from other causes (RRR 1.16) compared to children born of younger mothers. Maternal education was protective, with children born of mothers with some education having reduced risk of death from malaria (RRR 0.8) and deaths due to other causes (RRR 0.87). A higher wealth index (least poor) was protective with a risk reduction for death from malaria (RRR 0.76) and from other causes (RRR 0.62), and area of residence offered a reduction in the risk of dying of malaria and other causes for those living in urban areas (RRR 0.61 and RRR 0.67 respectively).

In terms of maternal age and education, it was interesting to note that there were more young mothers with some education compared to older mothers (Appendix G). For broader category, 21.2% of young mothers had some education compared to 10.1% older mothers. For more refined categories, 25.5% of mothers aged less than 20 years had some education compared to 20.1% of mothers aged 20-29 years, 11.0% of mothers aged 30-39 years, 6.6% of mothers aged 40-49 and 6.1% of mothers in the age group 50-55 years. This trend is however encouraging, in that it portrays a picture where we may expect more future young mothers to have access to some education going by the observation that there is a reversing trend were older women had no/little access to education with young girls and younger mothers now having increasing access.

**5.4 Limitations:**

The strength of this study is the wide coverage of the entire district in which the DSS is located and the data set provided adequate sample size. However, the most severe and often highlighted limitation is that DSS data describes relatively small, often geographically isolated populations that are not representative of the populations living in the larger political or geographic areas in which the DSS sites are located. This results in a fundamental disjuncture between the experience of a risk factor and the death event to which it may lead [42]. However, it is interesting to note that, despite this limitation, the findings from this study were highly consistent with those in the national survey over the same period[41] and were also comparable with other DSS findings.

The wealth index was derived using principal component analysis, but we had not included data on income/expenditure, as this was not available in the dataset. The other difficulty was to have supporting reference for the interpretation of the range of poverty, for which arbitrary categories were used (from poorest to least poor), comparatively like in other poor settings.

Another limitation of this study was that, the Verbal autopsy data that was used was not validated. There has been however a quality control carried out during each cycle. The quality of verbal autopsy data can be affected by many factors. One such factor can be the recall of the events leading to death. This may be affected by the time interval between death and the time when the interview is done. The longer the time interval, the more likely, the person will forget or give unreliable data, particularly in a place where literacy levels are low. In our study, interviews for verbal autopsy were conducted within a year of death for 88.1% of the study children with a mean and median of 2.98 and 2.4 months respectively. The remaining interviews (11.9%) took over a year to be conducted. Although VAs are not able to attribute cause of death as accurately as standard autopsies, they are reasonably accurate for most causes of death and usually provide reasonable cause of death distributions at the community level[43, 44,45,46,47.]

Regarding the cause of death from HIV infection, the VA did not diagnosed, this is because at the time of data collection, the information was not collected and HIV was uncommon and still remain low. The prevalence rate for Ghana in general stands at 3.4 and only 1% for the Upper East region where the study was carried out[48]..

There were other variables including birth order and preceding birth interval, survival status of mother, antenatal care attendance, distance from health facility and possibly effective bed net usage, which could have been interesting to explore their relationship and association with child mortality, but the existing data did not have the information to generate such variables.

As earlier explained, in a full dataset, 46% of the study children came from compounds that had no bed nets (27,377/59345). About 90% of the compounds (53,228/59345) that had nets, had less than or equal to four nets per compound and further analysis showed only 5% (2975/59345) had more than six nets per compound. There are several households per compound ranging up to 14, and being compound based data, it is difficult to indicate how many bed nets a household therefore possessed and whether or not under five children had access to those nets. We therefore did not take into consideration the number of nets a compound owned, but just looked at whether study children came from families/compound who owned bed net or not.

In the initial dataset, 19301 data was discharged due to missing value of child's date of birth. This leads to have an effect of information bias on the findings.

Lastly, in as much as the data used was longitudinal and prospectively collected, the study design to look at the association between child mortality and demographic and socio-economic factors was done in a cross sectional manner. Therefore the study suffered from the obvious limitations of cross-sectional studies, which are in general limited to gathering retrospective and current-status information. It is therefore difficult to establish a causal relationship between exposure and outcome variables. Specific to this study for example the multivariate multinomial logistic regression models show maternal age and level of education, wealth index of the family, child's sex and age group as determinants not as causes for child malaria or other cause mortality.

## CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

From this study it can be concluded that malaria remain one of the major cause of mortality in the district. It is however important to observe declining mortality rates from childhood malaria during the period under study. The study identified the risk factors (age and sex of the child and mother's age, maternal education, wealth and residence of the family) associated with malaria mortality and other causes of deaths in childhood in northern Ghana and this should help formulate cost effective interventions such as health education. Specifically, there was a clear demonstration of the dose response relationship between the poverty factors and mortality in the DSS. There was also a much high strength of association between age group of the child and mortality, and in particular, the risk was more for children between 1 and two years (coinciding with the weaning period). Effective and integrated information and communication by health care providers to the community will empower local communities to participate in more effective malaria control.

Various other studies have highlighted the fact that successful malaria control depends on effective community health education regarding the disease and personal protection and prevention measures [49, 50,51].

The consistency and the manner in which the findings compare with other DSSs study findings gives much credibility and reliability to using DSS data for assessing risk factors and also monitor mortality as a way of providing information in line with the MDG and other benchmarks developing countries have to meet.

In general, the findings of this study can be used as basis for a number of policy recommendations related to existing prevention and control strategy of malaria in the country. We have to bear in mind the fact that the identified determinants apart from demographic factors are all intricately related to the socio-economic status of the family and therefore highlights the effects of poverty on mortality. Poverty alleviation in this setting cannot be accomplished overnight. However, other approaches to minimising child malaria mortality can be easily implemented:

a. As already highlighted, health education on malaria related topics to mothers to empower them in the face of lower literacy levels particularly for older mothers.
b. Improved access to health care facilities including use of community health workers to facilitate health education and prompt treatment of malaria in the community and promote under five clinics more so during the weaning period.
c. There is need for a quick evaluation of the IMCI and review of its effective implementation to improve care of children in this resource limited setting, since we have observed the fact that same risk factors are at play for both malaria and other cause mortality, which needs an integrated approach.
d. In the long run, there is need for continued advocacy in the district, particularly during community feedback meetings to promote girl child education, which will in the end translate into improved maternal education.
e. Increase community awareness on effective use of bed nets including re-treatment of ITNs and not just ownership.

Finally, by considering this as base line information I recommend that, another evaluation study to look at the demographic and socio-economic factors related to child mortality in the period 2001 to 2005 be carried out to have a comprehensive picture and appreciate the impact of some of the strategies on child mortality, that were being put in place during the years 1997-2000 which included interventions using bed nets and also introduction of community nurses in almost all the villages/clusters of the NDSS .

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**APPENDIXES:**

**Appendix A: Table A.7. Multivariate Analysis With adjusted P-Values**

| Background characteristic | Died of Malaria<br>RR (95%CI) p-value | Died of other causes<br>RR (95%CI) p-value |
|---|---|---|
| **Sex of child** | | |
| Male | 1 | 1 |
| Female | 0.97 (0.88-1.08) 0.620 | 0.91 (0.84-0.98) 0.017 |
| **Age group of children** (Mean=1.8, std. dev. =1.4) | | |
| Infants | 1 | 1 |
| 1-<2 yrs | 1.56 (1.36-1.78) <0.0001 | 1.26 (1.14-1.40) <0.0001 |
| ≥2 yrs | 1.29 (1.13-1.47) <0.0001 | 1.06 (0.97-1.17) 0.209 |
| **Age group of mothers** | | |
| <30 | 1 | 1 |
| >30 | 1.28 (1.15-1.43) <0.0001 | 1.16 (1.07-1.26) <0.0001 |
| **Wealth index (quintiles) of family** | | |
| Poorest | 1 | 1 |
| Poorer | 1.05 (0.89-1.23) 0.592 | 1.00 (0.89-1.13) 0.955 |
| Poor | 1.07 (0.91-1.26) 0.421 | 0.89 (0.79-1.01) 0.076 |
| Less poor | 0.92 (0.78-1.09) 0.345 | 0.87 (0.77-0.99) 0.030 |
| *Least poor* | 0.82 (0.68-0.99) 0.049 | 0.65 (0.56-0.76) <0.0001 |
| **Residence** | | |
| *Urban* | 0.70 (0.51-0.96) 0.026 | 0.84 (0.67-1.05) 0.132 |
| Rural | 1 | 1 |
| **Bed net ownership** | | |
| *Family with* | 0.96 (0.86-1.07) 0.456 | 1.02 (0.94-1.11) 0.616 |
| Family without | 1 | 1 |
| **Education level of mother** | | |
| No education | 1 | 1 |
| Some education | 0.84 (0.71-0.99) 0.042 | 0.87 (0.77-0.99) 0.036 |

**Appendix B: Table B.8. Multivariate Analysis With Adjusted P-Values**

| Background characteristic | Died of Malaria RR (95%CI) | p-value | Died of other causes RR (95%CI) | p-value |
|---|---|---|---|---|
| **Sex of children** | | | | |
| Males | 1 | | 1 | |
| Females | 0.97 (0.88-1.08) | 0.620 | 0.91 (0.84-0.98) | 0.017 |
| **Age group of children** (Mean=1.78, std. dev. =1.35) | | | | |
| Infants | 1 | | 1 | |
| 1-<2yrs old | 1.56 (1.36-1.78) | <0.0001 | 1.26 (1.14-1.40) | <0.0001 |
| ≥2yrs old | 1.29 (1.14-1.47) | <0.0001 | 1.06 (0.97-1.17) | 0.202 |
| **Age group of mothers** | | | | |
| <20 | 1 | | 1 | |
| 20-29 | 0.94 (0.78-1.12) | 0.469 | 0.70 (0.61-0.79) | <0.0001 |
| 30-39 | 1.18 (0.98-1.42) | 0.078 | 0.84 (0.74-0.96) | 0.009 |
| 40-49 | 1.41 (1.12-1.77) | 0.004 | 1.02 (0.86-1.21) | 0.791 |
| 50-59 | 3.08e-20 | . | 1.34 (0.51-3.50) | 0.548 |
| **Wealth index (quintiles) of family** | | | | |
| Poorest | 1 | | 1 | |
| Poorer | 1.04 (0.89-1.22) | 0.617 | 1.01 (0.89-1.13) | 0.927 |
| Poor | 1.06 (0.90-1.24) | 0.484 | 0.89 (0.79-1.01) | 0.076 |
| Less poor | 0.91 (0.77-1.08) | 0.285 | 0.87 (0.77-0.99) | 0.032 |
| *Least poor* | 0.76 (0.63-0.91) | 0.003 | 0.62 (0.54-0.73) | <0.0001 |
| **Education level** | | | | |
| No education | 1 | | 1 | |
| Some education | 0.82 (0.69-0.97) | 0.019 | 0.87 (0.76-0.98) | 0.023 |

**Appendix C:**

**Figure C.4,: Graphs of wealth index**

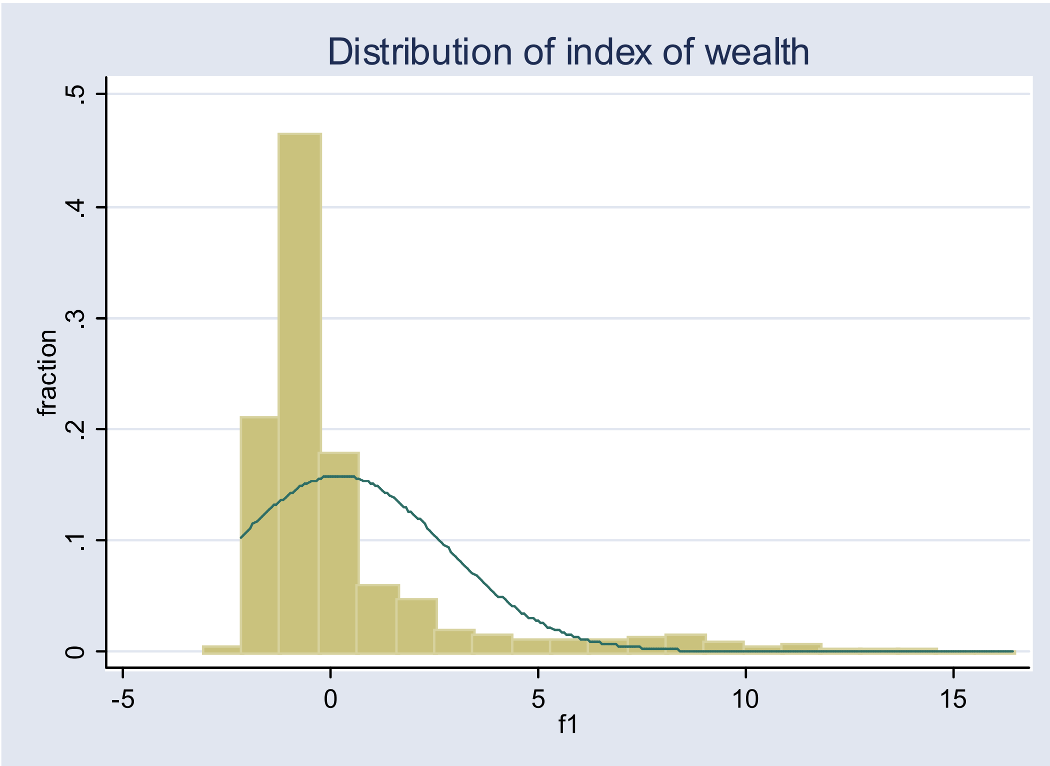
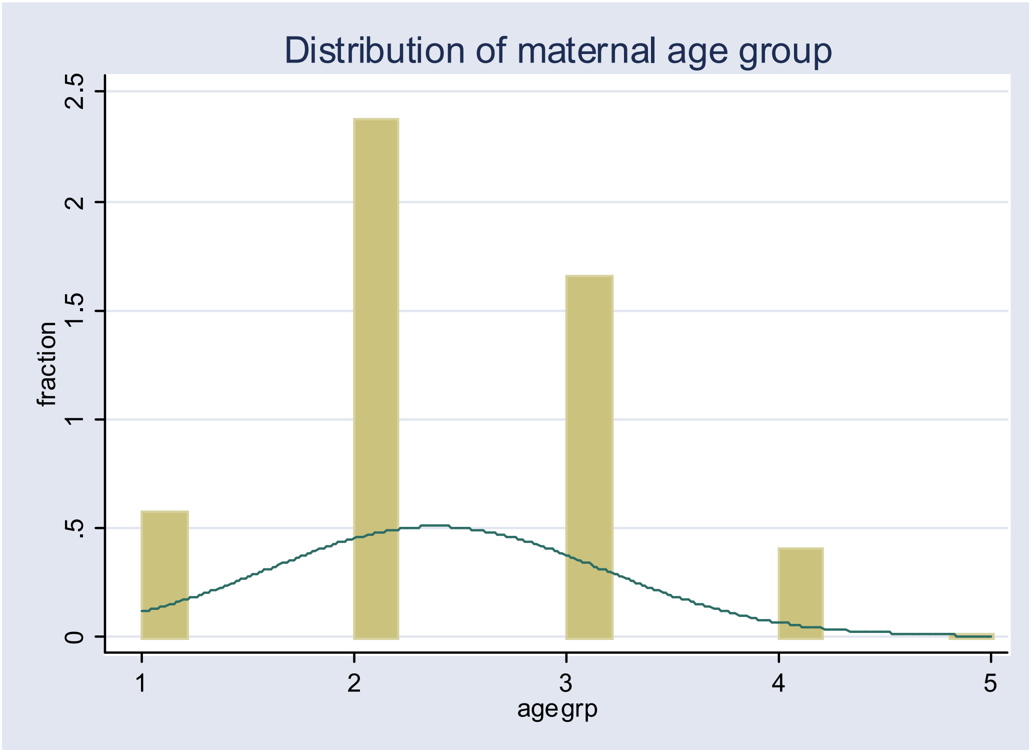


Figure C.5: Graph for and maternal age group



**Appendix D:**

Figure D.6,. Pie chart for maternal education

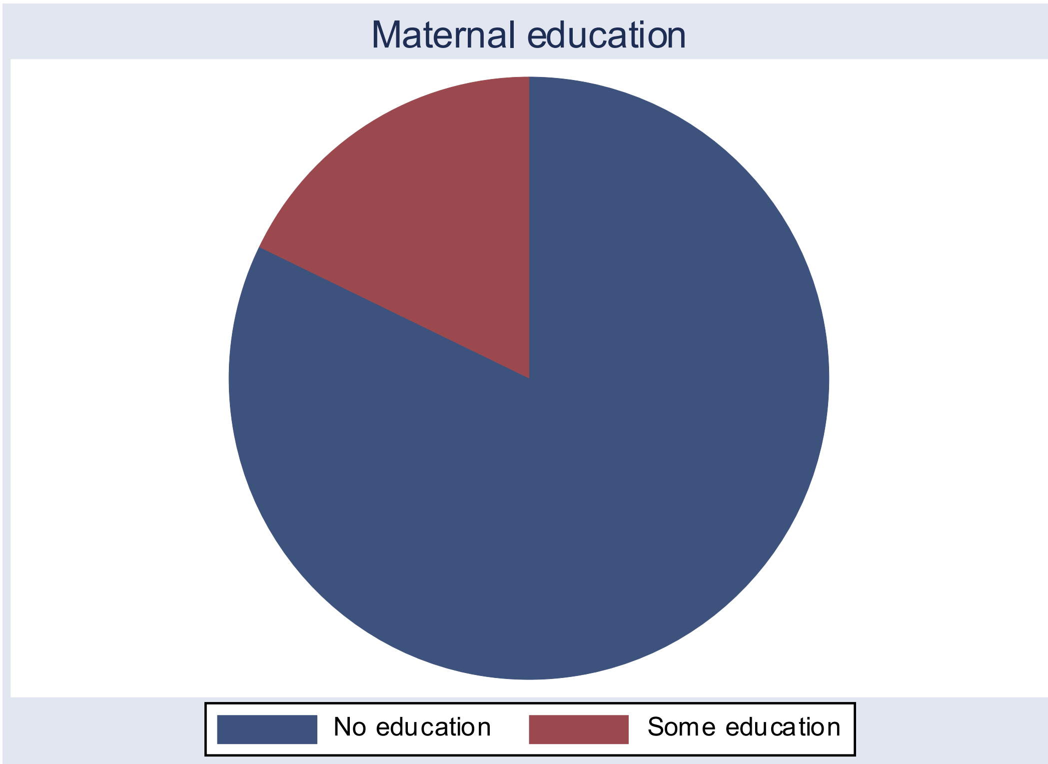
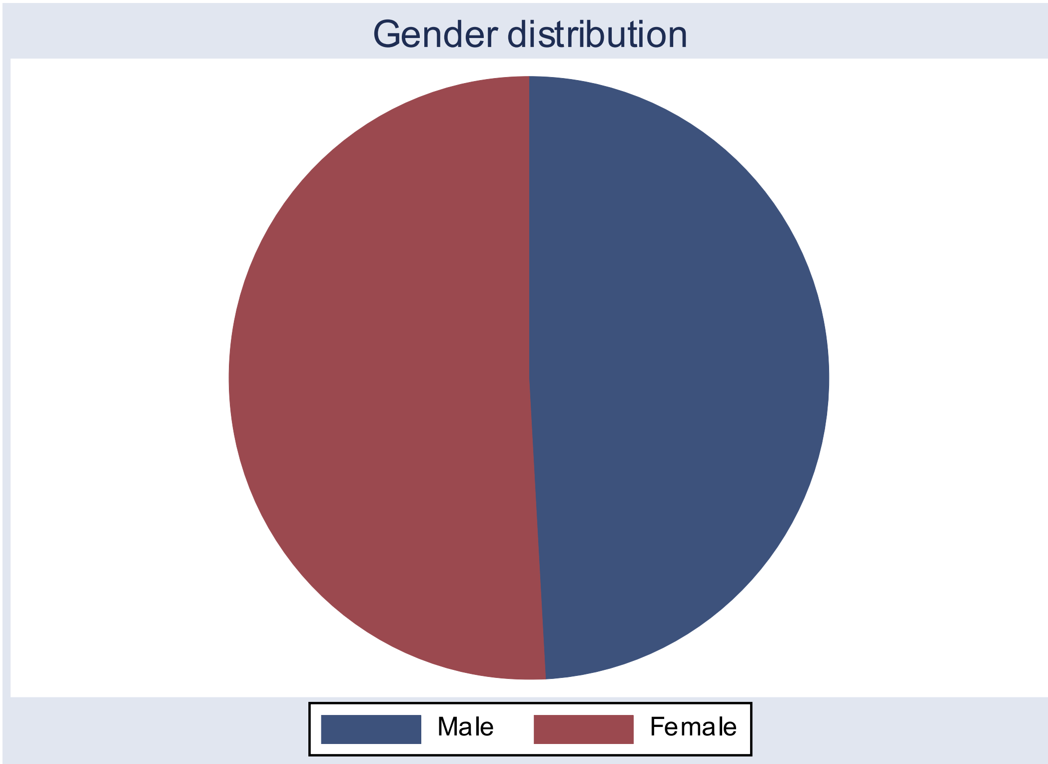


Figure D.7: Pie Chart for sex of the child



**Appendix E: Table E.9. Malaria mortality mean crude rates**

| Year | Number deaths due to malaria | Total population under five | Mean crude mortality rate | Lower confidence interval | Upper confidence interval |
|---|---|---|---|---|---|
| 1995 | 197 | 2491 | 79/1000 | 68/1000 | 91/1000 |
| 1996 | 332 | 4920 | 67/1000 | 60/1000 | 75/1000 |
| 1997 | 306 | 4772 | 64/1000 | 57/1000 | 72/1000 |
| 1998 | 282 | 5423 | 52/1000 | 46/1000 | 58/1000 |
| 1999 | 202 | 4545 | 44/1000 | 39/1000 | 51/1000 |
| 2000 | 186 | 7379 | 25/1000 | 22/1000 | 29/1000 |

**Appendix F: Table F.10. The odds of dying from Malaria relative to other causes**

| Year | Number deaths due to malaria | Number of deaths due to other causes | Odds | Lower confidence interval | Upper confidence interval |
|---|---|---|---|---|---|
| 1995 | 197 | 495 | 0.398 | 0.337 | 0.469 |
| 1996 | 332 | 590 | 0.563 | 0.492 | 0.644 |
| 1997 | 306 | 426 | 0.718 | 0.620 | 0.832 |
| 1998 | 282 | 378 | 0.746 | 0.639 | 0.870 |
| 1999 | 202 | 396 | 0.510 | 0.431 | 0.604 |
| 2000 | 186 | 390 | 0.477 | 0.401 | 0.568 |

**Appendix G: Table G.11. Cross tabulation of maternal age and education**

| | Education level | | |
|---|---|---|---|
| Age group of mother | No education | Some education | Total |
| Less than 20 yrs old | 2,666<br>74.55 | 910<br>25.45 | 3,576<br>100.00 |
| 20-29 yrs old | 10,958<br>79.92 | 2,753<br>20.08 | 13,711<br>100.00 |
| 30-39 yrs old | 8,709<br>88.98 | 1,079<br>11.02 | 9,788<br>100.00 |
| 40-49yrs old | 2,267<br>93.41 | 160<br>6.59 | 2,427<br>100.00 |
| 50-59yrs old | 31<br>93.94 | 2<br>6.06 | 33<br>100.00 |
| Total | 24,631<br>83.4 | 4,904<br>16.6 | 29,535<br>100.0 |
| Pearson chi(4)=719.96 Pr=0.000 | | | |

**Appendix H:**

Permission letter to use NDSS Data

**Appendix I:**

Human Research Ethics Clearance Certificate from the University of Witwatersrand

**Appendix  J:**

Navrongo Health Research Centre IRB Approval letter

**Appendix K:**

Navrongo DSS Census Form

**Appendix L:**

Verbal Autopsy Form for Child Death (extracted)

**Appendix M**

Consent for VA (Communication from Local supervisor – Cornelius Debpuur)

The Navrongo Demographic Surveillance System is a longitudinal population registration system established in the Kassena-Nankana district to support the research activities of the Navrongo Health Research Centre. The system was established in 1993 and has been running since. The verbal autopsy has been integrated into the DSS activities to provide an understanding of the causes of death in the Kassena-Nakana district.

As in all data collection of the Navrongo Health Research Centre, participation in the VA interview is voluntary. If a death has been reported a trained field supervisor visits the compound and use a comprehensive questionnaire to elicit information on the events leading to the death, as well as signs and symptoms the dead person exhibited in the days prior to the death. For child deaths the required information is usually obtained from the mother, father or caretaker. In the case of adult deaths, the preference is for the spouse, the caretaker during the illness or a close relative.

When the interviewer arrives at the compound, she/he sympathesizes with the family on the death of their member. He then identifies himself and the purpose of his visit to the family. Thereafter, he identifies the preferred respondent and requests his/her permission to ask some questions regarding the deceased and the events that led to his/her death. Approval for the interview is given verbally and there is no obligation on the respondent to grant an interview. If the timing is considered inappropriate an appointment is made to conduct the interview at a later time.

*Ethics clearance certificate*: No ethics clearance certificate for the DSS is available. In 1993 when the DSS was set up there was no ethical review process in place. It was only in 2002 that the NHRC IRB was set up.