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TITLE:

Risk Factors of Neonatal Mortality in Navrongo DSS in Ghana between 2001 and 2005

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DECLARATION

I, Seri Emily Maraga 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 Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Signature: ....

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29th October 2010

DEDICATION

I dedicate this work to the Almighty God for his wisdom and grace, my loving parents, my fiancé, family and friends for their continued prayer, support and encouragement during my studies.

May God Bless You All.

ABSTRACT

Background

Improvements in the health status of children have resulted in a substantive reduction in under-five mortality by two-thirds between 1960 and 1990. However this reduction is favourable for children after the first year in life, with little decrease in the neonatal period. Every year, about 4 million children die within the first 28 days of life, the first week (0-7 days) posing the highest risk. The Fourth Millennium Development Goal emphasises a reduction in child mortality by two-thirds by 2015, however this goal cannot be met because neonatal deaths continue to increase. It is therefore important to make available information on risk factors and the main causes of death that exist at a community level so that appropriate health policies are devised to reduce the mortality burden faced by neonates.

Objective

The study investigates the relationship between household and maternal socio-demographic characteristics with neonatal mortality in the Kassena-Nankana District from 2001 to 2005. The specific objectives were; (1) To calculate the neonatal mortality rates in the Kassena-Nankana District from 2001 to 2005, (2) To determine the causes of neonatal death for years 2003 to 2005, and (3) To assess the association of household characteristics and maternal socio-demographic characteristics with neonatal deaths in the Kassena-Nankana District from 2001 to 2005.

Methods

Data from Navrongo DSS in Ghana was used for the analysis. A total of 19 340 live births born from 15 224 households were registered between 1st January 2001 to 31st December 2005. Of these 551 died before the 28th day after birth. The outcome, neonatal mortality was coded as a binary variable and took values 1 if the child died and 0 if the child survived. Neonatal mortality rates were

calculated by dividing the total number of deaths for a particular year by the total number of live births for that year, multiplied by 1000. Cause of death data were collected using neonatal specific verbal autopsies. Cause-specific neonatal mortality rates were calculated using physician coding to a list of cause of deaths based on the 9th International Classification for Diseases (ICD). Using the mother's household characteristics and assets ownership, a wealth index was constructed as proposed by Filmer and Pritchett to estimate socio-economic status. Chi-square (x^2) test at 5% significant level was also done to compare the maternal socio-demographic and neonatal characteristics by neonatal mortality. Logistic regression models were fitted to assess the association between (i) neonatal mortality and socio-economic status (SES) and (ii) between neonatal mortality and maternal as well as neonatal risk factors, while adjusting for potential confounders. Health equity was measured using the concentration index (CI) and the poorest-poor ratio (PPR).

Results:

The overall neonatal mortality rate for the whole study period was 29 per 1000 live births. Most deaths (65.9%) occurred outside the health facility and most occurred in the early neonatal period (0-7 days). Infectious diseases (n=98, 33.2%), birth injuries (n=28, 9.5%) and prematurity (n=29, 9.8%) were the main causes of neonatal deaths. In the multivariate analysis maternal characteristic that showed an association with mortality were place of residence, SES, birth order and the type of birth outcome. Such that children who died were more often from the rural areas compared to in the urban areas (AOR=2.24 95% CI=1.16-4.34 P=0.016). Children who died were more often from a multiple birth outcome compared to those from a single birth outcome (AOR=0.20 95% CI=0.14-0.28 P<0.0001). SES was found to be protective against neonatal mortality (AOR=0.70 95% CI= 0.51–0.96 P=0.026). By birth order, children who died were more often from the 1st birth order compared to children of birth orders; 2-3 (AOR=0.60 95% CI=0.44-0.81 P=0.001), 4-5 (AOR=0.56 95%

CI=0.38-0.84 P=0.005) and 6^{+} birth order (AOR=0.50 95% CI=0.31-0.8 P=0.005). A measure of health equity gave a C.I of -0.07 and PPR of 1.29 implying that neonatal mortality was high amongst the poorest households than the better ones.

Conclusion

The study showed that neonatal mortality was high in the rural areas and in the poorest households. Efforts to alleviate the burden of neonatal mortality at a community level should focus on improving living standards for poorest in the community. Also educating women on child health care and making them aware of high risk pregnancy age-groups will help minimize risky pregnancies which in turn will reduce neonatal deaths.

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DEFINITION OF TERMS

1. Neonatal Mortality (NN): the probability of dying between birth and the first month of life

2. Wealth Index: Proxy measure of household wealth which is based on household characteristics and assets ownership (house ownership, source of drinking water, electricity, sanitation facility (toilet), floor material type, roof material type etc).

3. Concentration index (CI): Means of quantifying the degree of income-related inequality in a specific health variable. It measures the extent to which a variable is distributed unequally across all five socio-economic quintiles, i.e. the concentration of inequality. The closer the index is to zero, the less concentrated the distribution of inequality.

4. Verbal autopsy (VA): A procedure for gathering systematic information that enables determination of the cause of death in situations where the deceased was not medically attended to. It is based on the assumption that most common and important causes of death have distinct symptom complexes that can be recognized, remembered, and reported by lay respondents. It is a useful way to enhance the quality of mortality statistics in developing countries.

5. Demographic Surveillance System (DSS): This is 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 (INDEPTH Network).

6. Compound: a dwelling unit that houses a group of people who may or may not be related or share common resources, including feeding arrangements.

LIST OF ACRONYMS AND ABBREVIATIONS

MDG-4	Fourth Millennium Development Goals
HIV	Human Immunodeficiency Virus
AIDS	Acquired Immunodeficiency Syndrome
WHO	World Health Organization
KND	Kassena-Nankana District
NHRC	Navrongo Health Research Centre
NDSS	Navrongo Demographic Surveillance System
DSA	Demographic Surveillance Area
NMR	Neonatal Mortality Rate
CSNMR	Cause Specific Neonatal Mortality Rate
SES	Socio-Economic Status
PCA	Principal Component Analysis
CI	Concentration Index
INDEPTH	International Network for Continuous Demographic Evaluation of Populations and their impact on Health in Developing Countries
MoH	Ministry of Health
CHFP	Community Health Family Planning Program
CHO	Community Health Orderly
HRS	Household Registration System
PPR	Poorest to least poor mortality rate ratio
VA	Verbal Autopsy
ICD	International Classification of Diseases

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CHAPTER ONE: INTRODUCTION, LITERATURE REVIEW, AIMS AND OBJECTIVES

1.1 Introduction

The fight against poverty, illiteracy, killer diseases like HIV/AIDS and malaria, civil conflicts, inadequate physical infrastructure and low health-system capacities are common hardships faced by less developed countries and sub-Saharan Africa (SSA) is no exception. These impediments have contributed to the high burden of child mortality (1). Child mortality not only measures the level of child health and the overall development of a country but it is a reliable and excellent indicator in monitoring progress to achieving the Millennium Development Goals (2).

The Fourth Millennium Development Goal (MDG-4) emphasizes a reduction in child mortality by two-thirds between 1990 and 2015. Improvement in health status of children globally has resulted in a substantive reduction in under 5 child mortality by half between 1960 and 1990 (3). The progress to achieving the MDG-4 is underway, however it has been slow and unequally distributed with 93 countries (representing 40% of the world's population) meeting the MDG-4; 51 (48% of the population) showing slow progress and 43 (12% of the population) show stagnation or reversing trends (2). Despite impressive global reductions in the risk of under-five child mortality, this is favourable to children after the first month in life with little decrease in the neonatal period (first 28 days of life) (4;5). The number of child deaths in this period continues to increase and the Millennium Development Goal for child survival cannot be met without substantial reductions in neonatal mortality.

Every year about 4 million children die within the first 28 days of life (accounting for almost 40% of under 5 mortality), and about three-quarters of these deaths occur in the first week, the first day of life posing the highest risk. About 98% of neonatal deaths occur in low and middle income countries and the risk of dying in the neonatal period is eight times greater in developing than developed countries

(3;6;7). In developing countries, neonatal death rates remain high because half of these deaths occur at home, and in infants who are not seen by health professionals in their final illness (8). Several studies conducted on under five mortality have established vast knowledge on environmental, socio-economic and behavioural factors as risk factors for under five mortality (6). Findings from such research work have resulted in health intervention programs ensuring child survival and safe motherhood. However, neonatal deaths have not been the focus of these interventions (8).

In Ghana, a five-year period Demographic and Health Survey data (conducted in 1988, 1993, 1998 and 2003) has shown a declining trend in both infant and under five mortality in the first three earlier surveys (1984-1998) except for the recently conducted survey (1998-2003) which displays a halt in the mortality rates (9). This halt is believed to have been caused by an increase in the neonatal mortality rate from about 30 per 1000 for 0-4 years preceding the 1998 surveys to 43 per 1000 for the same period prior to the 2003 survey (10). This slow decline in mortality also reflects the economic instability and health systems struggle the country faces in achieving a reduction in poverty levels, which targets an infant mortality rate of 50 per 1000 and an under five mortality of 95 per 1000 by 2005 (11). Mortality levels in Ghana are considerably and consistently higher in rural areas compared to the urban areas; thus suggesting that the true burden of neonatal mortality may be underestimated and will cause Ghana fail to meet the MDG 4 goal.

The Kassena-Nankana District in Ghana is mainly rural with Navrongo (the district capital) having sub-urban characteristics. Although health services provided by the Ghana Ministry of Health (MoH) and through health interventions by the Navrongo Health Research Centre (NHRC) have resulted in improvements in health status of the people in the district, newborns in the neonatal period have the highest risks of mortality. To address this public health issue, risk factors posed to newborns at a community level must be identified. This study therefore aims to contribute to the limited knowledge on the risk factors for neonatal mortality from a rural perspective and to contribute to the realization of the Millennium Development Goal for newborn survival.

1.2 Problem Statement

In Africa, the neonatal mortality rate is high (41 neonatal deaths per 1000 live births) and the distribution in the Sub-Saharan region in the Eastern, Western and Central Africa range between 42 and 49 neonatal deaths per 1000 live births (3;6;7). Every year about 300 000 African babies die on the first day of their birth (12). Like many other countries in the Sub-Saharan regions, babies born in Ghana are at risk of dying in the neonatal period. A large number of studies conducted in Ghana have led to improvements in health status of Ghanaians yet infant and child mortality remains high. A study conducted by the Ghana Demographic Health between 1998-2003 for under-five mortality reported a drop in under-five mortality by 28% (44 per 1000 live birth) with a reduction of 72% for the 12-59 month age group, 26% for the 1-11 months age group while neonatal mortality remained unchanged (13). Another study by Baiden et al on the trend and causes of neonatal mortality in the Kassena-Nankana district of northern Ghana used verbal autopsy data for the period 1995 to 2002. This study reported that on average neonatal mortality rate declined by 2.5 per 1000 live births per year for the period reviewed. Overall, a reduction of nearly 50% from 40.9 (95% C.I. 34.1–46.8) in 1995 to 20.5 (95% C.I.17.3–22.7) in 2002 was observed. This decline is not a result of a neonatal specific intervention, but rather a result of vast health research activities undertaken within the district over the years (14). From both studies it is clear that the magnitude of the problem may be underestimated due to variations in rates reported which is clearly due to inadequate data available on neonatal deaths especially in the absence of vital registry systems at the community level. This tragic state has not only contributed to the lack of interventions aimed at reducing neonatal mortality but it also calls for more studies aimed at neonates to ensure availability of more accurate data on risk factors and causes of neonatal morbidity and mortality for appropriate policies to be devised (5).

1.3 Justification for the Study

Despite countless studies conducted on neonatal mortality, most studies are health facility based and are not reflective of those deaths that occur at home in a rural setting where health care services are minimal. Separate studies conducted in rural Gambia (15) and Tanzania (16) found that 84% of neonatal deaths and >40% of perinatal deaths occurred at home. The use of the Verbal Autopsy (VA) has provided an alternative measure to determining the cause of death of neonates and this would help in achieving the Millennium Development Goal for child survival (MDG-4) in low income areas where neonatal deaths remains an important public health issue. Hence, in order to further reduce the burden of neonatal mortality, risk factors at a community level must be identified and appropriate interventions devised to address them.

1.4 Literature Review

1.4.1 Causes of Neonatal Mortality

Globally, the direct causes of neonatal death are preterm birth (28%), severe infections (26%), and birth asphyxia (23%). Neonatal tetanus accounts for a smaller proportion of deaths (7%) and is easily preventable. Low birth weight (LBW) is an important indirect cause of death (7;17).

A study conducted in Nigeria on pregnancies that were booked for antenatal care but delivered outside the health facilities with the aim of determining the perinatal outcome of these pregnancies, comparing to those that were booked and delivered within the health facility. The study showed that, birth asphyxia was most common in the study group (outside health facility delivery) (48 (14.3%)) than in the control group (health facility delivery) (16 (4.8%)). This difference was statistically significant ($P<0.001$). Also neonatal infection or tetanus was significantly common in the study group

(22 (6.5%)) than in the control group (8 (2.4%)) ($P<0.01$). Birth trauma also showed a statistically significant difference between the study group (10 (3.0%)) and the control group (2 (0.6%)) ($P<0.05$) (18). Another cohort study of unselected pregnant women in rural Malawi reported that preterm delivery (>24 and <37 completed weeks) occurred in 92 (20.3%) of the 453 women; 72 (16.0%) of these women delivered between 33 and 37 completed weeks, and 20 (4.4%) between 24 and 32 completed weeks. Babies born between 36 and 37 completed weeks were twice as likely to die as babies born at term (6.9% versus 3.4%) but this difference did not achieve statistical significance. For those children born between 24 and 33 weeks gestation there was a significant increase in perinatal mortality (75% versus 4.4%, $p<0.0001$). The high preterm rates was thought to be infection-related (19).

Many studies conducted on birth weight and childhood mortality in different ecological settings have shown that neonates born with very low birth weight (LBW) are at greater risk of dying (20;21). Maternal complications such as ante partum haemorrhage, obstruction or prolonged labour, eclampsia, prematurity and premature rupture of the membranes increases the risk of perinatal mortality. A study on maternal labour complications in a district hospital in Kenya showed that perinatal death risk was increased between 8- and 62-fold and accounted for 53% of perinatal deaths (22).

1.4.2 Maternal characteristics and Neonatal mortality

Maternal characteristics are strongly associated with newborn outcome. Mothers who live in poverty stricken areas with poor health status are more likely to give birth to children who are underweight or who have a higher risk of dying in the neonatal period. Literature has shown that maternal characteristics like the maternal age at childbirth, parity, birth order, birth interval, birth type (singleton or multiple), educational level, marital status, socio-economic status and accessibility to health care all play an important role in child survival (21).

Historical and prospective studies of populations have shown birth order and maternal age to have similar effect on mortality. Firstborn infants, as well as those of higher birth orders, were found to have a considerably higher mortality than the intermediary births. This effect was also observed for the age of mothers. Death of infants born to very young mothers (<20) and to older mothers (>30) was considerably higher than that of infants born to mothers ages 20-30 years. The lowest rate was recorded for mothers' aged 27-28 years (23-25).

Marital status also influences child survival because it can be used as a proxy to assess nutrition, housing and overall economic status (26). However a study on teenage pregnancy showed that the high risk disappeared in younger mother's when controlling for socio-economic status, thus suggesting that neonatal deaths result more from social disadvantage than from maternal factors (27).

The relationship between maternal education and neonatal mortality is complex but several studies have demonstrated reduced rates of infant and child mortality in association with increased levels of maternal education (28;29). The advantage of mothers being educated and having high survival chances of their children is due to access to better health care. Also being educated is associated with better chances of accessing income or being employed (30;31)**.** Low income is associated with low education and it is a major barrier in accessing health services in developing countries. However, the benefit goes beyond having better income. The knowledge aspect of being educated can make a difference. For example, in a poor household, knowledge can make the difference between using a piped water source, better toilet facility, washing of hands before eating, how to take care of the sick, etc. Knowledge plays a major role in such things as securing a nutritious diet and making appropriate use of health care services.

Household characteristics like source of water, place of residence, number of rooms in the house and the numbers of people living in the house, etc, all affect child mortality. These factors do not directly cause mortality but act through other intermediate variables like nutrition, access to health services, environment, etc. Studies conducted on household characteristics also showed a positive correlation with neonatal mortality.

1.4.3 Summary of Gaps on Research work done on Neonatal Mortality

The turn of the twentieth century witnessed a substantive reduction in under-five mortality; however neonatal mortality rates have remained unchanged. Despite extensive research work on neonates with the aim to reduce mortality levels, only a few of these studies are applicable to the Sub-Saharan Africa (SSA) region. This is because in SSA, the effort goes beyond monitoring mortality levels. The mortality levels are used as a direct measure of the health status of populations and an indirect measure of the effects of economic, political, and epidemiological hardships faced by the region (32). The few studies conducted in SSA looked at neonatal deaths in communities where (i) people had no access to health services due to their geographical locations, financial status or their socioeconomic status and (ii) non existence of proper death registry systems. This study intends to address these research gaps by contributing knowledge on risk factors affecting neonates at a community-level in the Kassena-Nankana District which is situated in a low and middle income setting in SSA.

1.5 Research Question

Are maternal socio-demographic and household characteristics risk factors for neonatal mortality in the Kassena-Nankana district in Ghana?

Hypothesis:

Maternal socio-demographic and household characteristics are risk factors of neonatal mortality in the Kassena-Nankana district.

1.6 Aim

The aim of this study is to determine the association between household, maternal socio-demographic characteristics and neonatal mortality in the Kassena-Nankana district from 2001-2005.

1.7 Specific Objectives

1. To calculate the neonatal mortality rates in the Kassena-Nankana district from 2001-2005.
2. To determine the causes of neonatal deaths in Kassena-Nankana district from 2003-2005
3. To assess the association of household characteristics and maternal socio-demographic characteristics with neonatal deaths in Kassena-Nankana from 2001-2005

1.8 Conceptual Framework of Study

The framework for this study was adapted from the Mosley and Chen analytical framework on child survival in developing countries. To date this model is widely used in many epidemiological studies on child survival (33). The Mosley-Chen framework is based on the premise that most social, economic, cultural, and health system variables operate through a set of proximate determinants to influence child mortality. These proximate determinants can be grouped into five groups; maternal factors (age, birth order); environmental contamination, nutrient deficient, injuries and personal illness control.

Though the framework for this study is adapted from the Mosley and Chen model, it is similar to a study conducted in Indonesia by Titaley et al on determinants of risk factors for neonatal mortality (20). In the Titaley study, risk factors were analyzed at three different levels; the community, the household and the individual level. In this study we concentrate on risk factors existing at the household and individual level. The conceptual framework on how the proposed risk factors influence neonatal mortality in the Kassena-Nankana District is shown in Figure 1.1.

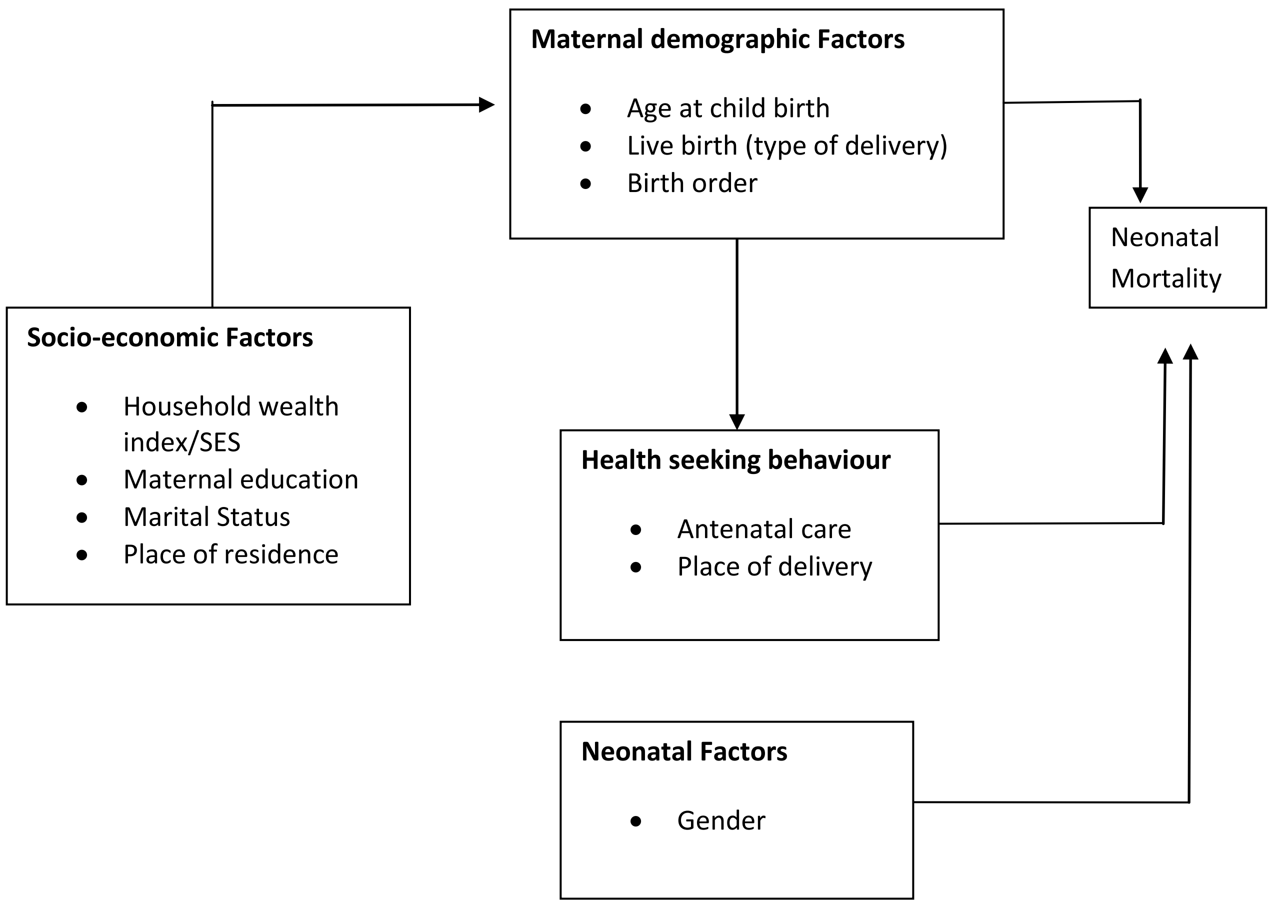

Figure 1.1 Conceptual Framework showing Inter-relation of Risk Factors for Neonatal Mortality

As depicted in Figure 1.1 the risk factors can be grouped as socio-economic variables (maternal education, wealth index, place of residence and marital status) and demographic variables further grouped as maternal factors and neonatal factors (mother's age at child birth, child's age, the child's gender, birth order and live births).

Socio-economic variables do not directly influence neonatal mortality per se but affect it through association with other factors (proximal determinants) as shown by the arrows. Household economic status and sanitary conditions (exposure to disease) are important determinants of childhood mortality. For example; homes that have access to piped water supply, use electricity as their main source of energy for cooking, have flush toilets and own a car generally may be wealthier and have good health status than those homes without these assets (34;35). A woman's marital status indirectly influences mortality. Union status of an individual can result in improved SES, better nutrition and source of income to access health services. For example; an illiterate woman who marries a literate man can have an improved health status such that her attitude may be influenced by her husband. He would cause her to provide nutritious meals for her family, better care for the children and have better knowledge about diseases and access to health services. Studies have also shown that women not in a proper union are perceived to have low health status (36). For example; teenage mothers are usually, dropouts from high school and poor. These women are emotional and psychologically vulnerable because they lack both financial and social support from their families or societies due to accepted marital practices in societies. Several studies have shown elevated risk of mortality in pregnancies that lack social and emotional support, especially from the husband or partner (37;38).

The mother's education level affects child survival (39) by influencing the choices she makes with regard to nutrition, hygiene, preventive care and treatment for diseases. For example; women who have some education tend to reside in urbanized areas, utilize effectively available health service if their children fall ill. Their homes have access to cleaner water supply and flush toilets. Being educated enables one to get better paid job to buy nutritious food and it enhances high compliance to treatment which is a key factor in the healing process. Also they can alert physician if they observe unusual signs or behaviour seen in their newborn child (40;41). A study in Australia showed that children born to socio-economically disadvantaged mother's had the worst health status (42). The gender of the child in the framework is directly associated with mortality because it is not influenced by any other factor.

CHAPTER TWO: METHODOLOGY

This chapter describes the population characteristics of the study area (KND), the NDSS, the study design and study population. The chapter also explains how the variables were defined and measured, how the data was managed, what analysis technique was used and lastly what ethical measures were taken to ensure data confidentiality and dissemination of results.

2.1 Population characteristics of the study area

The Navrongo Demographic Surveillance Site (NDSS) is located in the Kassena-Nankana District (KND) in the Upper East region of Ghana. The district covers a land area of 1674 km^2 with a population of 148 372 as of June 2008, giving a population density of about 86 persons per sq. kilometre. The two distinct ethno-linguistic groups are the *Kassena* (forms 54% of the district's population) and the *Nankani* (about 42%) with *Builsa* and migrants belonging to other ethnic groups making up the remaining 4%. The main languages spoken are *Kassim* and *Nankam*, with *Buili* being spoken by most of the minority tribe. Most people are Christians and followers of traditional religions and few Muslim. The population is predominantly rural with subsistence farming as the mainstay of the district's economy. The major agricultural products are groundnuts, millet, guinea corn, rice, sorghum, sweet potatoes, beans and tomatoes. Rearing of cattle, goats, sheep, pigs, fowls and guinea fowls also form part of the agricultural activities. Literacy levels are quite low with more than 70% of the population being illiterate. Like many rural areas in Africa, it still has strong holds on traditional beliefs and customs. Infanticide, locally referred to as 'chichuru' is a customary practice among some communities within the district. It is the act of killing children who are believed to be born with supernatural powers that could be harmful to the family into which they are born to. This practice adds to the under-reporting of neonatal deaths. Male dominance in decision making prevents woman from making autonomous decisions on health issues and influences their access to health services. For example, curative and preventive health care may not be sought without the permission of the male spouse or, in his absence, the head of the compound (43). The district also has an orphanage which is managed by the Catholic mission. About 89% of the houses in the district are mud huts with thatched roofs. The main sources of water supply in the district are streams, wells and boreholes although a few urban houses have pipelines installed to provide treated water. Only 7% of the compounds have access to properly constructed toilet facilities, suggesting that 93% of the houses use the bushes in their immediate surroundings. For those compounds with toilet facilities, two-thirds use Kumasi Ventilated Improved Pit Latrines (KVIPs), pan or pit latrines, while the rest use water closets.

2.1.1 Health service provision and organization

There are eight health centres located in selected communities and a main district hospital located in the urban centre. As part of the Ghana Ministry of Health and the National Health Insurance policy, free health services are available to all under fives, pregnant women and those aged 70 years and above. Leading causes of child morbidity and mortality come from malaria, diarrhoea, respiratory tract infections and meningitis.

2.2 Navrongo Demographic Surveillance System (NDSS)

2.2.1 Field Operations

The NDSS is a longitudinal household registration system, set up in July 1993 by the Navrongo Health Research Centre (NHRC) with the objective of monitoring population dynamics of the KND and serves as a platform for health research in a typical rural setting. Since its establishment it has been collecting information on demographic events (birth, death, pregnancies, marriage, in and out migration) at a compound level. 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. Routine updates on these events are conducted on a 90 days cycle by trained field staff. Quality assurance for each update is achieved through re-interviewing a 3% random sample selection of the population by a quality control supervisor. In addition, information on vaccination status of children less than 2 years and education status of persons six years and above is collected annually. Pregnancies recorded earlier are also monitored during these quarterly visits until they are terminated. This helps improve the reporting of births and deaths through capturing neonatal deaths in particular.

Although data collected at a compound level has led to successful completion of many research works in the last quarter of 2004, the NDSS switched data collection from compound level to household level so as to enhance the distribution of the information collected. This not only stimulates local and global interests to issues of equity and how they affect health, but for comparison purposes with fellow DSS sites and survey data which are collected at a household level. Verbal autopsies are also conducted on all deaths that occur to registered members in the Demographic Surveillance Area (DSA). VA interviews are conducted by VA trained supervisors using specific standardized questionnaires. Completed forms are coded independently by three physicians to determine the probable cause of death. In cases where there are disagreements, the case is coded as undetermined and is set aside for further discussions.

2.2.2 Socio-demographic Characteristics of the DSS Population

The DSS has registered a total of 15 000 compounds as of June 2005 with a population well over 144 787. The population is young with about 39% under 15 years and about 3% who are 65 years and above thus giving an age dependency ratio of 72.4% (dependency ratio is equal to the number of individuals aged below 15 plus the number of individuals above 64 divided by the number of individuals aged 15 to 64,expressed as a percentage). Females constitute 52.5% (76 013/144 787) of the population thus giving a sex ratio of 90.5%, this means that there are about 91 men for every 100 women. Migration to the southern parts of the country is common during the dry seasons when there is virtually no farming activity.

2.3 Study population

The study population includes all live births from women aged 15-49 years registered within the DSA between 2001 and 2005.

2.4 Study design

This study was a longitudinal study using secondary data of the NDSS. All variables on the household asset questionnaire and selected variables from the neonatal death specific VA questionnaire were used for the purposes of this study.

2.5 Study Sample

On average about 4000 births occur every year with neonatal deaths accounting for 5.5% of all cause of death in the district. It was estimated that out of a total of 4000 births, about 220 babies would die in the neonatal period. Since neonatal death rates are low in the area, a longer study period (from 2001-2005) was chosen to obtain a large enough sample size for analysis. This large sample would also take into account misclassification and inconsistencies in the database.

2.6 Inclusion and exclusion criteria

The study sample included only live births to women 15-49 years registered within the DSA from 1st January 2001 to 31st December 2005. Live births to women below 15 years and above 49 years during this study period were excluded.

2.7 Data Source and Measurement

Data for this secondary analysis study was extracted from the NDSS database which includes information on all individuals, household head, household assets and deaths and its causes which occurred between the1st January 2001 to 31st December 2005.

2.8 Description and Extraction of study variables

2.8.1 Explanatory variables

The two main exposure variables were (i) **Maternal socio-demographic characteristics** and

(ii) **Household characteristics (wealth index/SES)**

Broadly these variables include socio-economic, demographic and health outcome predictor variables. The socio-economic variables used in the study include wealth index, marital status and mothers' highest educational level. The demographic variables used were the mother's age at child birth, child's age, the child's gender and place of residence (urban / rural) birth order and type of birth outcome. While the health outcome predicting variables included place of delivery/birth, place of death, delivery assistant and cause of death for the neonates.

Socio-economic variables:

a) Maternal education: The education level of the mother was determined on the basis of formal education and years spent in school. The current system of school in Ghana has Primary, Junior High School, Senior High School and then college or university. For this variable we found that higher levels of education after junior secondary and above had fewer observations. For convenience of analysis the variable was re-categorized into 4 groups. *'None'* for those who had never been to school, *'Primary'* for those who attained a primary education level, *'Secondary +'* for those who attained a junior high school, senior high school and higher college or university. A total of 1651 mothers' analyze in the study had a missing education record and so were omitted during analysis.

b) Wealth Index/SES: Data on income was not available to measure socio-economic status (SES) of the households; thus SES was obtained by using asset data collected on households and applying the Principal Component Analysis (PCA) technique to construct the wealth index/SES. This asset approach has been used by many studies (44-47) in developing countries where income and expenditure data is not a precise measure of living standards but rather a collective measure of consumption or expenditure are reliable and easier to collect in these areas where assets like ownership of farmland may be reflective of wealth in rural areas. PCA reduces the number of variables in a dataset into a smaller number of dimensions. In mathematical terms, from an initial set of n correlated variables, PCA creates uncorrelated indices of components, where each component is a linear weighted combination of the initial variables. For example, from a set of variables X_1 through to Xn,

$PC_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots\ldots a_{1n}X_n$

$PC_m = a_{m1}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots a_{mn}X_n$ where

a_{mn} represents the weight for the m^{th} principal component and the n^{th} variable (48).

The following household characteristics and assets were included in the PCA model: household durable assets (car, bicycle, DVD, etc) water usage, sanitation facilities, power source and housing quality (wall type, floor type, roof type); animal possessions, land ownership and availability of food. The model was based on the presence or absence of each asset or the nature of the housing materials .i.e. each asset was coded with the response, 1 and 0; 0 for the absence of the asset and 1 for its presence. This was achieved using the 'pca' command in STATA 9 to generate a list of indices for all the assets. Then using the first principal component (which explains most variability) the households were divided into quintiles (i.e. poorest, poorer, poor, less poor, and least poor) that represent the proxies for SES. All children were placed in a wealth index group except for 2346 records that did not have information on household assets as this asset information was collected only in 2004. Hence, most houses abandoned or demolished before 2004 would have missed out. However, this limitation is spread equally across both comparison groups in the study.

The idea of employing the household characteristics as a proxy for SES in assessing its relationship with mortality is prudent and simple. The basic idea behind information on household possessions is that households with piped water, flush toilets, a finished cement floor, roofing made from metal, use of electricity for cooking, or those that possess a variety of consumer goods (ranging from a car, or a motorbike to a radio, VCR) are more likely to achieve good health status than those without these facilities or those that rely on surface water, pit latrines, mud floors, etc. Also the household possessions are considered an indication of the level of affordability of good health services and some are markers of the capacity for personal hygiene (49).

c) Health Equity (Concentration Index-CI): Health equity in neonatal mortality was measured using the concentration index (CI) as proposed by Wagstaff et al (50). The concentration index is defined as twice the area between the concentration curve and the line of equality (51).The index takes on a negative value when the concentration curve lies above the line of equality, meaning that the inequality is greatest among the poor. Alternatively, a positive concentration index indicates that the concentration curve is below the line of equality and it implies that the health variable is concentrated among the rich (52). The CI is similar to the relative index of inequality that is frequently used by epidemiologists (53;54). The concentration curve is usually drawn using the cumulative percentages of the ranked economic status variable on the x-axis relative to the cumulative percentages of the health variable on the y-axis. For instance, if everyone irrespective of his or her economic status has the same value of the health variable, the concentration curve or line of equality will be a 45^{o} line. On the other hand, if the health variable takes value among the poorest, the concentration curve will lie above the line of equality and conversely if the health variable takes value among the richest, the concentration curve will lie below the line of equality. In effect, the farther the concentration curve is away from the line of equality, the greater the level of concentration with respect to that health variable among the poor or the rich.

d) Marital status: This variable took the following values: 'never married', 'married', 'divorced/separated', 'widowed' or 'living together'. This variable has limitations because it is a time-changing variable, however the NHRC does not collect it regularly as would have been expected. The variable was then categorized as *'Never married'* or *'Married'.*

Demographic variables:

e) Mother's age at childbirth: The longitudinal data does not directly collect mother's age but it could be generated using the mother's date of birth and the child's date of birth. For this study it was computed by subtracting the birth date of the child from the mother's date of birth.

f) Age of the child: This variable gives the age of the neonate at death. It was measured in days because of the short period of observation (0-28 days after birth). The age variable was generated by subtracting the child's date of birth from the child's date of death. This date of death was restricted to 0-28days only. Those children that survived beyond 28 days or died after 28 days were excluded from this variable. All those children who fell within day 0 and 28 days were further categorized as *'Early neonatal'* those neonate aged 0-7 days and *'Late neonatal'* those aged 8-28 days.

g) Type of birth: This variable looked at the number of live births at the time of delivery. The variable took values '1' singleton, '2' twins and '3' triplet. In the dataset, this variable showed fewer observation for the 'twins' and 'triplet' categories, hence the variable was re-categorized to *'single'* for a birth resulting in one live birth and *'multiple'* for a birth that results with more that one live birth. Of the 18 797 live births analyzed, 2.9% (543/18 797) of the children had no information on this variable.

h) Birth order: This variable recorded the position of the child amongst other siblings in the family. There were 11 categories ranging from 1-11 representing the child's ranking at birth. The variable was re-categorized into four groups; *'1'* 1st born child, *'2-3'* 2nd and 3rd born, *'4-5'* 4th and 5th born, *'6+'* includes 6th born and above.

i) Gender of the child: This was a string variable that had two values 'Male' or 'Female'. The variable was coded as *"O" representing males "1" representing females*.

j) Place of residence: Apart from the compound identification number and the unique permanent ID, each child in the study had information on the locality of residence. Of all the localities identified in the DSA, 10% of these are classed as urban zones. In the dataset, there were 2 unique values *'1' urban areas* and '2' *rural areas*.

Health Outcome variables

All information on delivery assistant, place of birth, place of death and cause of death variables under health outcome were collected from the neonatal specific VA questionnaire that was introduced in 2003 as an initiative of the INDEPTH network to standardize the VA tool in collaborating DSS sites. Also this meant that neonatal deaths that occurred prior to 2003 had no such information collected. These variables were further dropped out in the univariate and multivariate analysis as information on these variables applied to the dead.

k) Delivery assistant: This variable had these categories 'Health Professional', 'Trained TBA', 'Untrained TBA', 'Relatives' or 'Others'. Of all the births registered, only 5% (1016/19 340) of the children had information available on this variable.

l) Place of birth: This variable was primarily categorized as '1' Hospital, '2' Health centre/Clinic, '3' Home, '4' Traditional Birth Attendants home and '5' Others. Again some categories had too fewer observations and so broader categories were considered for ease of analysis. The variable was re-categorized by combining categories 1 and 2 as *'In Health Facility'* and 3, 4 and 5 as *'Outside Health Facility'*.

m) Place of death: This variable had the following categories: 'Hospital', 'Other Health Facility', 'On the way to hospital or health facility', 'Home' or 'Others'. Since some categories had fewer observations broader categories were considered and the variable was re-categorized by combining 'Hospital', 'Other Health Facility' as *'In Health Facility'* and 'On the way to hospital or health facility', 'Home' or 'Others' as *'Outside Health Facility'*.

n) Cause of Death: Causes of death were grouped into broader categories: *'Prematurity', 'Infections', 'Birth Injury', 'Infanticide', 'Others' and 'Undiagnosed'*. This variable was used to assess causes of death related to the neonates as well as primary and secondary causes of death related to the mother. Data for this variable were extracted only for those children who died from 2003 to 2005 due to the fact that a previous study had already analyzed and published death information for years 2001 and 2002 (14). For years 2003-2005, a total of 295 neonatal deaths were recorded with 72.5% (214/295) having a probable cause of death determined using the VA questionnaire. About 70.5% (208/295) of these deaths were analyzed while 2.0% (6/295) were dropped due to data discrepancies. Table 2.1 gives a summary of all variables of interest and their definitions.

Table 2.1: Study Variable and their Definitions

No	Variable	Definition
Maternal socio-economic and bio-demographic characteristics		
1	Wealth index (quintiles)	composite index of household asset ownership of land and animals/ food accessibility 1=Poorest; 2=Poorer; 3=Poor; 4=Less Poor; 5=Least Poor
2	Mother's age at child birth (years)	age of mother at childbirth 1=<20 ; 2=20-25 ; 3=26-35; 4= >35)
3	Maternal highest education level	1=None; 2=Primary; 3=Secondary+
4	Marital status	whether the mother is married or not 1=Married 2=Never married
5	Birth order	birth order of child compared to other siblings in the family 1=1st born; 2=2nd & 3rd born; 3=4th & 5th born; 4=6+ include 6th born and above
6	Type of birth	number of live children at birth 1=multiple ; 2= single
7	Place of residence	maternal residence :1=Urban; 2=Rural
Child related variables		
8	Age of the child (days)	age of the child 1=Early (0-7 days), 2=Late (8-28 days)
9	Gender of child	sex of the neonate: 0=Male ; 1=Female
Health outcome predictor variables		
10	Place of birth	where the child was born: 1=In Health Facility, 2=Outside Health Facility
11	Place of death	where the child died: 1=In Health Facility, 2=Outside Health Facility
12	Delivery assistant	who assisted during childbirth: 1=Health professional; 2=Trained TBA**; 3=Untrained TBA; 4=Relatives
13	Cause of death	1= Infectious causes, 2=Birth injury, 3= Prematurity, 4=Others and 5=Undiagnosed.

****TBA=Traditional Birth Attendant**

2.8.2 Outcome variable

The outcome measured was defined as neonatal mortality. A neonatal mortality was defined as is the death of child in the first 28 days of life. **Neonatal mortality rate** (NMR) was measured by dividing the total number of deaths for a particular year by the total number of live births for that year. The rate was expressed per 1 000 live births. A binary variable was generated and took the value 1 if a neonate died and 0 if alive. Babies who died within this period were compared to those who survived the same period.

2.9 Data Management

The NDSS data was entered using the HRS2 software (Visual FoxPro). The data was exported from Visual FoxPro to STATA version 9 and transferred using ODBC (Open Database Connectivity). Data extraction, cleaning, merging of tables and statistical analysis were done using STATA version 9. All study variables were extracted from various tables that make up the NDSS database namely the residency, individual, pregnancy outcome, birth, death and baseline socio-economic assets. The total number of death was obtained from the death table of all resident individuals in the DSA. The main database (DB) used for analysis was known as the **"neo-mortality DB"**; created by linking the "**cod DB**" and the "**baseline socio-economic status DB'** to the **"mortality DB"** which was renamed as the **"neo-mortality DB".** The **"socio-economic status DB"** contained information on the type of asset and number of assets owned by a household; while the **"cod DB"** had all neonatal deaths that occurred from 2003 to 2005. The date of birth was obtained from the birth table was used to link the individual and the birth table. Using the date of birth, all live births from 1st January 2001 to 31st December 2005 were extracted and saved as "**mortality database"**. All live births were used in the final analysis. For each birth a corresponding information on the mother's maternal characteristics (for example age at childbirth, education, etc) and the health outcome of the pregnancy (for example birth order of child, place of birth, etc) were extracted from the different tables of the NDSS DB. All this information was linked to the mortality DB using respective table unique identifiers. The **"socio-economic status DB"** and "**mortality DB"** were linked using the social group unique identifier. This ensured that every child was linked to a particular compound/household and ensured that several children born to the same compound/household be identified individually. For example; if 2 children were born to household CAD 342 in the same year, both births were taken as individual observations in the study period.

For the cause of death, all deaths that occurred from 2003 to 2005 were extracted into a separate dataset as cause of death "**cod database**". The cause of death database was linked to the main analysis dataset using the child's unique identifier. The data cleaning process involved checking of data quality in terms of missing values, internal inconsistencies and validity in responses.

2.10 Sample for analysis

The study sample involved all live births from 1st January 2001 to 31st December 2005 in the Demographic Surveillance Area (DSA) of NDSS. About 19 804 children were found in 30 738 compound/households that were eligible for inclusion in this study. On merging of personal data with household socio-economic status characteristics, 19 340 children in 15 224 households were included in the analysis. This yielded a child age range of 0-1825 days for the whole study period. A total of 2066 deaths were recorded in the DSA from 2001 to 2005 out of which 551 occurred in the first 28 days of life.

2.11 Data Analysis

2.11.1 Neonatal Mortality rates for 2001-2005

Neonatal mortality rate (NMR) was measured by dividing the total number of deaths for a particular year by the total number of live births for that year. This rate was expressed per 1 000 live births.

2.11.2 Measuring socio-economic status (Household characteristics/Living conditions)

The wealth index constructed using PCA method was then used to assess the relationship of SES and neonatal mortality using logistic regression.

2.11.3 Measuring Health Inequality

The PPR and CI were used to assess distribution of mortality by the different socio-economic groups.

2.11.4 Univariate and multivariate analysis

Chi-square (χ^2) tests were done to measure the association between exposure variables and the outcome variable. Both univariate and multivariate Logistic regression analysis was used to determine the association between SES, maternal characteristics and mortality in neonates. Potential confounders like mother's age, mother's education, marital status, socio-economic status/ wealth index, age of child, gender of child, birth order (parity), type of birth (singleton or multiple) and place of residence were adjusted for in the multivariate model. All these variables were included in the multivariate model based on evidence shown by literature of their association with mortality regardless of their significance level in the univariate analysis.

The final multivariate logistic regression model was given by:

$$\log [p/1\text{-}p] = \alpha + \beta 1x1 + \beta 2x2 \ldots.. \beta\ i\ xi$$

Where p= is the probability of a newborn dying within the first 28 days of life; x1 to xi are the explanatory variables which were fitted into the model; α is the intercept term (constant) and β1…. β i the regression coefficient related to the explanatory variables in the final model regardless of whether or not they were significant at the 5% level (55). Corresponding p-values and confidence intervals were calculated to test for statistical significance at 5% level.

2.12Ethical Approval

Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of Witwatersrand, Protocol number M080978 (Appendix 2). Also ethical approval was given for the use of the NDSS dataset by the Navrongo Health Research Centre Institutional Review Board, number NHRCIRB 076 (Appendix 3). In compliance with the Navrongo Health guidelines for conducting health research, findings from this study will be shared with the NHRC and the DSS communities.

2.12.1 Confidentiality

The data was used only for the purposes of this study. Confidentiality and anonymity were ensured by use of unique identifiers in identifying all study subjects.

2.12.2 Dissemination of the results

The findings of this study were shared with the NHRC and the Navrongo DSS community. It was also presented to the scientific community of the INDEPTH-Network and the University Of Witwatersrand School Of Public Health. The results from the study will be published in a peer reviewed scientific journal.

CHAPTER THREE: RESULTS

This chapter presents the results of this study. The statistical part was split in two parts; the descriptive and analytical analysis. In the descriptive analysis, we looked at the general socio-demographic characteristics of the children, their mothers and how these characteristics were distributed between the two comparative groups; the alive and dead. Then we calculated the neonatal mortality rates (NMR), the cause-specific neonatal mortality rates (CSNMR) and measured the socio-economic status (wealth index/SES) using the PCA technique. In the analytical analysis we investigated the relationship between the socio-economic risk factors and neonatal mortality using Logistic regression.

3.1 Socio-demographic characteristics of the study participants

The socio-demographic characteristics of the children and their mothers are presented in Table 3.1. A total of 19 340 live births born to 15 224 households were available for analysis. Live births were not uniformly distributed over the observation period with 2003 having the highest percentage 20.6% (3988) of live births than other years. For example 3853 births (19.1%) occurred in 2004 while 3688 births (19.9%) occurred in 2005 (Fig 3.1).

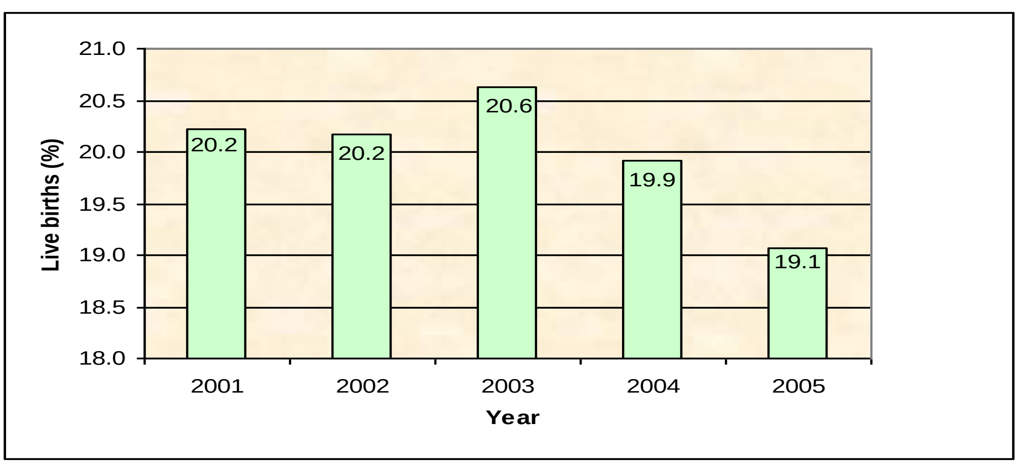

Fig 3.1 Distribution of live Birth in the KND between 2001 and 2005

Children in the study were almost equally distributed amongst male (50.8%) and female (49.2%), most (96.1%) being older than 28 days. The mother's ages ranged between 15 to 48.9 years with a mean and standard deviation of 28.9 and 7.17 respectively. Most children (39%) were born to mothers aged 26-35 years while mothers younger than 20 years had the least births (12.5%).

Table 3.1 Socio-economic and demographic Characteristics in the KND between 2001 and 2005

Variable	Category	Frequency (n)	Percentage (%)
Total live births	Alive	17 274	89.3
	Died	2 066	10.7
Mother's age at child birth (yrs)	<20	2 423	12.5
	20-25	4 799	24.8
	26-35	7 446	38.5
	>35	4 672	24.2
Mother's education	None	12 385	70.0
	Primary	2 710	15.3
	Secondary +	2 594	14.7
Marital status	Married	17 173	88.8
	Never Married	2 167	11.2
Place of residence	Urban	1 374	7.1
	Rural	17 966	92.9
Wealth Index++ (n= 19 340)	Poorest	3 988	23.5
	Poorer	3 793	22.3
	Poor	3 908	23.0
	Less Poor	3 539	20.8
	Least Poor	1 766	10.4
Child's gender	Male	9 824	50.8
	Female	9 516	49.2
Child's age (days)	<=28	755	3.9
	>28	18 585	96.1
Birth order	1	5 263	27.2
	2-3	6 700	34.6
	4-5	4 874	25.2
	6+	2 503	12.9

Type of birth*+	Single	18 347	97.6
(n= 18 797)	Multiple	450	2.4
Delivery assistant*+	Health Professional	280	53.0
(n=1 016)	Trained TBA	144	27.3
	Untrained TBA	20	3.8
	Relatives	84	15.3
Place of birth*+	In Health Facility	4 880	33.2
(n=14 723)	Outside Health Facility	9 843	66.9
Place of Death*+	In Health Facility	1 212	59.0
(n=2 054)	Outside Health Facility	842	41.0
TOTAL		**19 340**	**100.00**

***Missing information not presented in table above: Mother's education (1651) Wealth index (2346); Type of birth (543); Delivery assistant (18 812) Place of birth (4617) Place of death (17 286)**
+ Information collected from Neonatal specific VA; module introduced in 2003
++ Household information collected only in 2004

Most (92.9%) births occurred in the rural areas and about 70% to mothers' with no formal education. About 97.6% of the births registered were singleton births with 2.4% resulting in a multiple birth outcome. Most (59%) deaths occurred in a health facility. By birth order, most children were of the 2nd-3rd birth order (34.6%) while birth order 6th and above had the least number (12.9%). Of the 14 723 children analyzed in the study who had information on the place of birth most (66.9%) of the deliveries recorded occurred outside the health facility. Of the few children (1016) who had information on birth assistant, most (53%) were delivered by a health professional while 3.8% by an untrained TBA.

3.2 Socio-Economic Status using the Wealth Index

Information on household possessions, housing type and characteristics, food availability, animal possession, water usage, toilet and waste disposal was used to construct the wealth index. There were 41 principal components according to the number of asset items included in the analysis. The first 8 components cumulatively explained 50.1% of the total variance, the first component accounting for 21.2% of the total variance while the second component accounted for 8.3% (Fig 3.2).

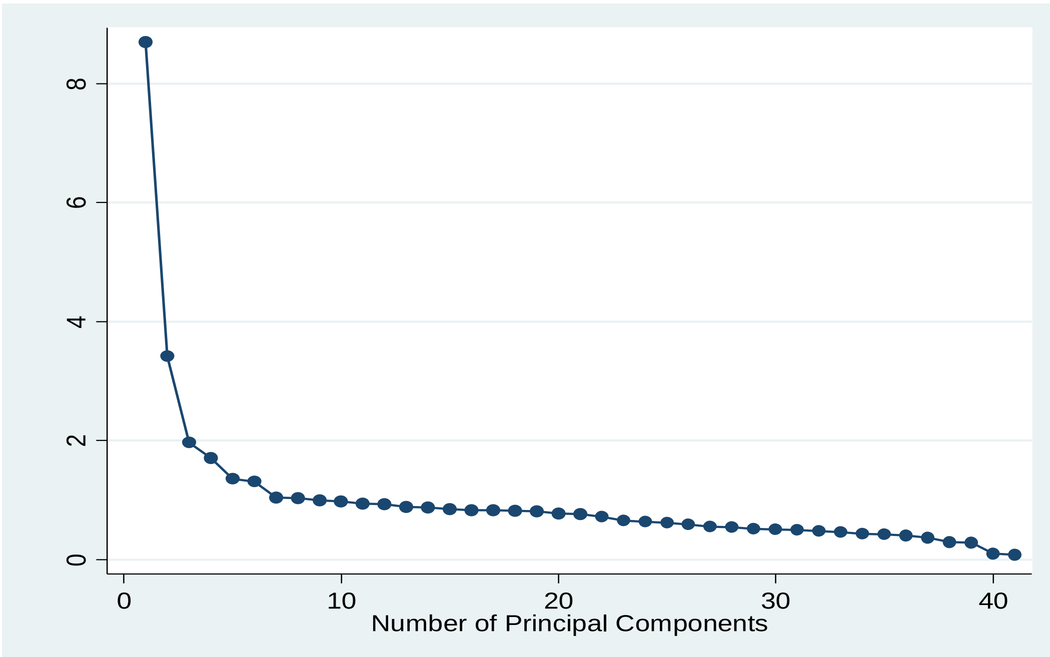

Fig 3.2 Scree Plots of Principal Components and Eigenvalues

Using the first component, a wealth index was constructed for each household in which each child resided in. The distribution of assets by SES (wealth index) is summarized in Appendix 4. As expected, a comparison of asset distribution amongst the quintiles showed that the least poor (better off) were more likely to own more assets compared to the poorest, however a reverse trend was shown for land and animal ownership.

In terms of SES and health outcomes, differences in health related indicators (like mortality) imply that the index is sensitive to differences. Similarly births were not uniformly distributed by SES quintiles with most births occurring amongst the poorest [3 988 (23.5 %)] compared to the least poor [1766 (10.4%)]. Chi-square tests at 5% level of significance were calculated to show the association of study variables and neonatal mortality as shown in Table 3.2.

Table 3.2 Distribution of live Births between the comparative Groups in the KND between 2001 and 2005

Variable	Alive (n, %)	Died (n, %)	Total	P-value
Total live birth	**18 789 (97.1)**	**551 (2.9)**	**19 340 (100)**	
Mother's age at childbirth (yrs)				
<20	2 315 (95.5)	108 (4.5)	2 423 (100)	<0.0001
20-25	4 650 (96.9)	149 (3.1)	4 799 (100)	
26-35	7 281 (97.8)	165 (2.2)	7 446 (100)	
>35	4 543 (97.2)	129 (2.8)	4 672 (100)	
Mother's education				
None	12 035 (97.2)	350 (2.8)	12 385 (100)	0.980
Primary	2 635 (97.2)	75 (2.8)	2 710 (100)	
Secondary +	2 522 (97.2)	72 (2.8)	2 594 (100)	
Marital status				
Married	16 694 (97.2)	479 (2.8)	17 173 (100)	0.160
Never Married	2 095 (96.7)	72 (3.3)	2 167 (100)	
Place of residence				
Urban	1 349 (98.2)	25 (1.8)	1 374 (100)	0.017
Rural	17 440 (97.1)	526 (2.9)	17 966 (100)	
Wealth Index[1]				
Poorest	3 863 (96.9)	122 (3.1)	3 985 (100)	0.085
Poorer	3 685 (97.1)	109 (2.9)	3 794 (100)	
Poor	3 805 (97.2)	108 (2.8)	3 913 (100)	
Less Poor	3 465 (97.9)	74 (2.1)	3 539 (100)	
Least Poor	1 721 (97.6)	42 (2.4)	1 763 (100)	
Child's gender				
Male	9 537 (97.1)	287 (2.9)	9 824 (100)	0.539
Female	9 252 (97.2)	264 (2.8)	9 516 (100)	
Child's age (days)				
Early neonatal (0-7)	58 (13.6)	369 (86.4)	427 (100)	<0.0001
Late neonatal (8-28)	146 (44.5)	186 (55.5)	328 (100)	
Birth order				
1	5 052 (96.0)	211 (4.0)	5 263 (100)	<0.0001
2-3	6 546 (97.7)	154 (2.3)	6 700 (100)	
4-5	4 755 (97.6)	119 (2.4)	4 874 (100)	
6+	2 436 (97.3)	67 (2.7)	2 503 (100)	
Type of birth[1]				
Single	17 870 (97.4)	477 (2.6)	18 347 (100)	<0.0001
Multiple	405 (89.9)	45 (10.1)	447 (100)	
Place of birth[1]				
In Health Facility	4 763 (97.6)	117 (2.4)	4 880 (100)	0.115
Outside Health Facility	9 563 (97.2)	280 (2.8)	9 843 (100)	
Place of Death[1]				
In Health Facility	850 (70.1)	362 (29.9)	1 212 (100)	<0.0001
Outside Health Facility	656 (77.9)	186 (22.1)	842 (100)	
Year				

2001	3 782 (96.8)	127 (3.2)	3 909 (100)	0.007
2002	3 773 (96.7)	129 (3.3)	3 902 (100)	
2003	3 877 (97.2)	111 (2.8)	3 988 (100)	
2004	3 774 (97.9)	79 (2.1)	3 853 (100)	
2005	3 583 (97.2)	105 (2.8)	3 688 (100)	

1= missing cases not shown in table
P-value= chi-square p-value

The mother's age at birth (P<0.0001), the child's age (P<0.0001), birth order (P<0.0001), type of birth (P<0.0001), delivery assistant (P<0.0001), place of death (P<0.0001) and place of residence (P=0.017) were found to have a significant association with neonatal mortality.

A total of 551 (2.9%) neonatal deaths were registered in the five year period, most (2.9%) occurring in the rural areas, and to children in the early neonatal 369 (86.4%) age group. Male children 287 (2.9%) had a higher proportion of deaths compared to female children 264 (2.8%); however the difference between both groups was not statistically significant.

Children to mother's with no education had the highest (350) number of neonatal death. However, relative across all education levels, mortality remained the same with about 2.8% for all levels while differences in neonatal deaths between the different maternal age groups was statistically insignificant (p>0.05). Children of birth orders 1 and 6^+ had higher proportions of deaths with 211 (4.0%) and 67 (2.7%) respectively while birth orders 2-3 and 4-5 had the least deaths with 2.3% and 2.4% respectively. Mortality differences between the different categories of birth order was statistically significant (p <0.0001).

Children born to woman who were not married had the highest proportion (3.3%) of neonatal death compared to those who were married (2.8%); however these differences were not significant. Children from multiple birth outcomes had higher proportions (10.0%) to death than survival compared to those children from single birth outcomes. Children in the poorest households also had the highest number of deaths (3.1%) compared to those born to the least poor households (2.4%), and again the differences were insignificant (P=0.085).

3.3 Neonatal Mortality Rates (NMR)

Neonatal deaths rates were calculated for each year and plotted as shown in Fig 3.3.

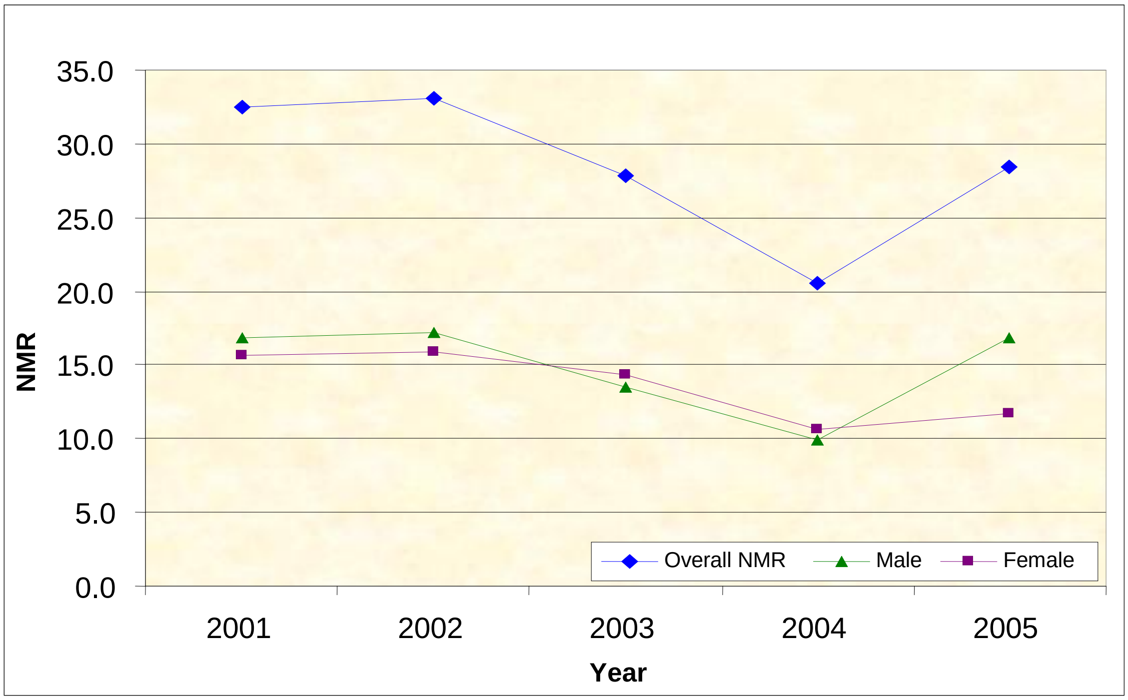

Fig 3.3 The Overall and Gender-specific Neonatal Mortality Rates in KND between 2001 and 2005

A slight increase was observed in the mortality rate in 2001 (32.5) to 2002 (33.1), followed by a decreasing trend in 2003 (27.8) to 2004 (20.5); then in 2005 (28.5) an increase was observed again. This increase is not because there was an increase in neonatal deaths but rather a result of better reporting of pregnancies. The Navrongo DSS changed from collecting data at a compound level to collecting data on vital statistics at the household level. This increased the accuracy of the data reported at household level and explains the apparent increase. Overall the trend shows a gradual decline in mortality. This observed mortality trend is similar to those published reports by NDSS.

A further analysis (data not presented) was conducted to see if there would be major differences in mortality rates between those presented and after exclusion of children with missing information on maternal education (1651) and wealth index (2346). The results obtained showed only minor differences in the mortality rates in both analyses suggesting that the rates found by the study are not distorted by omission of missing cases.

3.3.1 Cause-Specific Neonatal Mortality Rates (CSNMR)

We analyzed cause of death data for years 2003 to 2005 and the distribution amongst gender, age and place of delivery are presented in Table 3.3. Out of 295 neonatal deaths analyzed 208 had their probable cause of death determined using the VA.

Table 3.3 Frequency Distribution of Neonatal Mortality in KND between 2003 and 2005

Variable	Frequency (n)	Percentage (%)
Child's age		
0-7 days	118	56.7
8-28 days	90	43.3
Child's gender		
Male	104	50
Female	104	50
Place of death		
In health facility	71	34.1
Outside health facility	137	65.9
Total	**208**	**100**

Of the 208 that had a probable cause of death, most (65.9%) deaths occurred outside the health facility. Deaths were equally distributed amongst males (50%) and females (50%); most (56.7%) occurring in the early neonatal period (0-7 days).

Both infectious causes (36%) and birth injuries (23%) were the main causes of death in the early neonatal age group (Fig 3.4a) while infectious causes (62%) was the main cause of death in the late neonatal age group (Fig 3.4b).

Figure 3.4 Percentage distribution of Cause of Death by Age group in the KND between 2003 and 2005

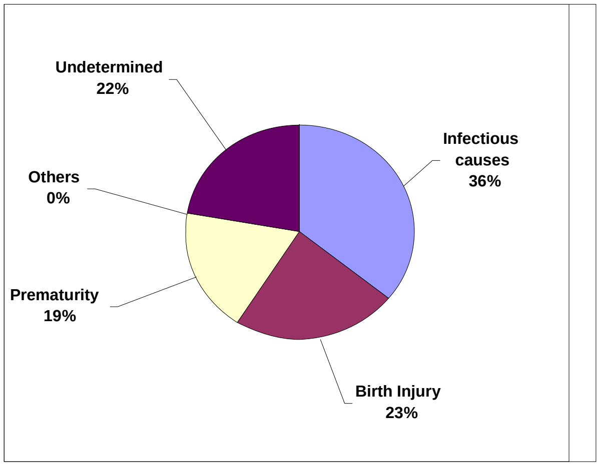

Fig 3.4a Causes of Early Neonatal Deaths (n=118)

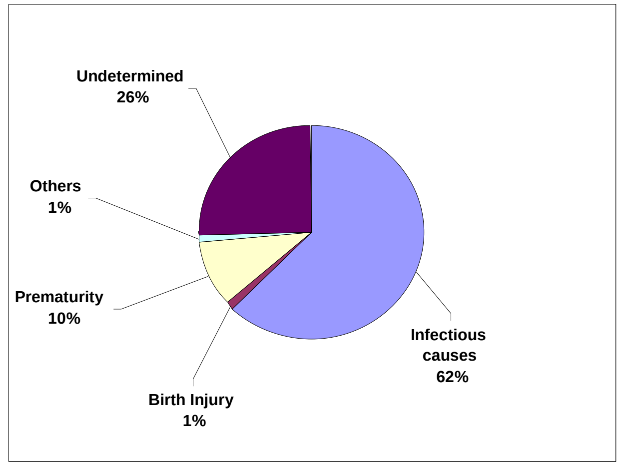

Fig 3.4b Causes of Late Neonatal Deaths (n=90)

Overall, infectious diseases (33.2%), prematurity (9.8%) and birth injuries (9.5%) were the three main causes of neonatal mortality (Table 3.4).

Table 3.4 Number, Rates and main Causes of Neonatal death between 2003- 2005 in KND using the Verbal Autopsy

	Year					
	2001	**2002**	**2003**	**2004**	**2005**	**Total (%+)**
No. of live births	3909	3902	3988	3853	3688	19 340
No. of deaths	127	129	111	79	105	551
NMR*	32.5	33.1	27.8	20.5	28.5	
Infectious causes			46	28	24	98
CSNMR**	-	-	46.9	28.6	24.5	33.2+
Birth injuries	-	-	10	9	9	28
CSNMR**	-	-	35.7	32.1	32.1	9.5+
Prematurity	-	-	13	9	9	29
CSNMR**	-	-	41.9	29.0	29.0	9.8+
Others	-	-	0	1	2	
CSNMR**	-	-	50.0	-	50.0	0.7+
Undetermined	-	-	13	13	23	49

Note:
+Percentage of death=Cause- specific death / cumulative deaths for 2003-2005 (295)
***NMR- Neonatal mortality rate**
****CSNMR- Cause-specific neonatal mortality rate**

All three causes of neonatal mortality showed a declining trend in the cause-specific rates from 2003-2005. Infectious causes and prematurity showed the greatest decline from 2003-2005; infectious causes from 46.9% to 24.5%, prematurity from about 42% to 29% and birth injuries from 36% to 32% (Fig 3.5).

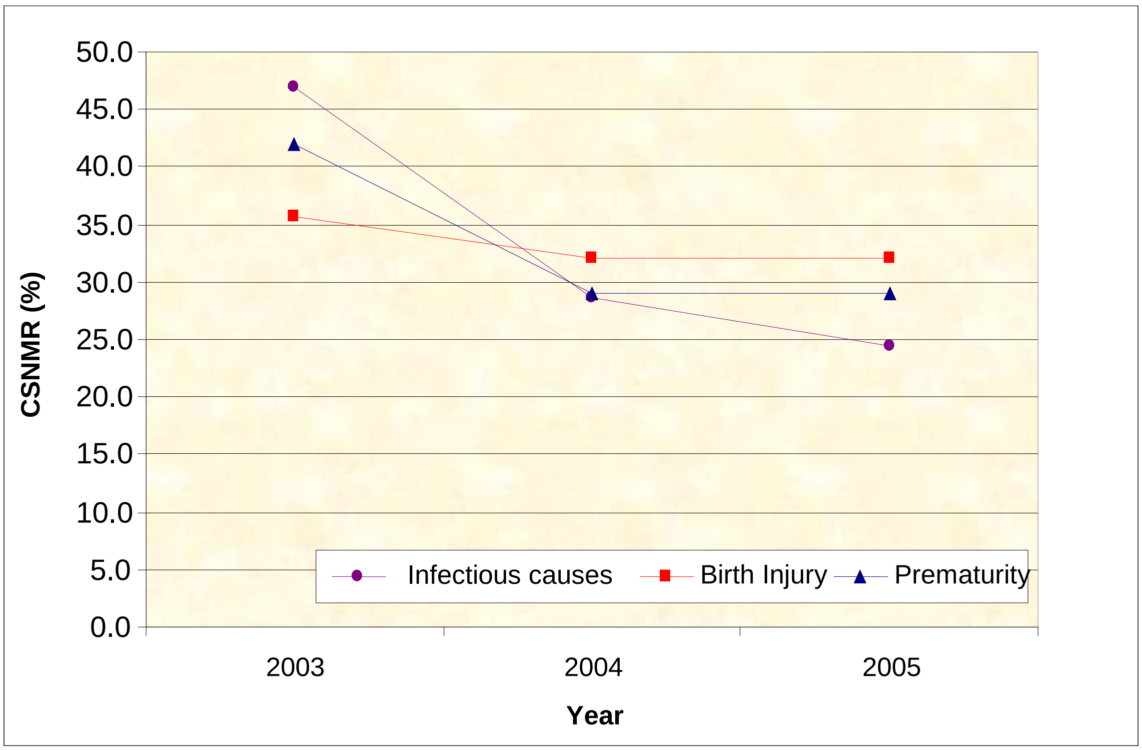

Fig 3.5 Cause-specific Neonatal Mortality Rates in KND from 2003 to 2005

3.4 Socio-economic status (wealth index) and neonatal mortality

All children observed in the five year period (2001-2005) were grouped into five quintiles according to the wealth index. Figure 3.6 shows the distribution of neonatal mortality across the different SES groups. When mortality was compared across the different SES groups, a declining trend in mortality was observed with increasing SES; however this was not consistent with the fourth quintile which had a lower mortality rate than the fifth quintile. A standard $\chi 2$ test on the mortality trend showed that there were no differences in mortality between the different SES quintiles ($\chi 2$=7.77 p=0.10).

A $\chi 2$ test of linearity was insignificant ($\chi 2$=1.77 p=0.62) whilst the $\chi 2$ test of slope remained significant ($\chi 2$ of slope =6.0 p=0.01). Overall, the linear trend depicts a significant relationship between mortality and socio-economic status ($\chi 2$=8.08 p=0.04).

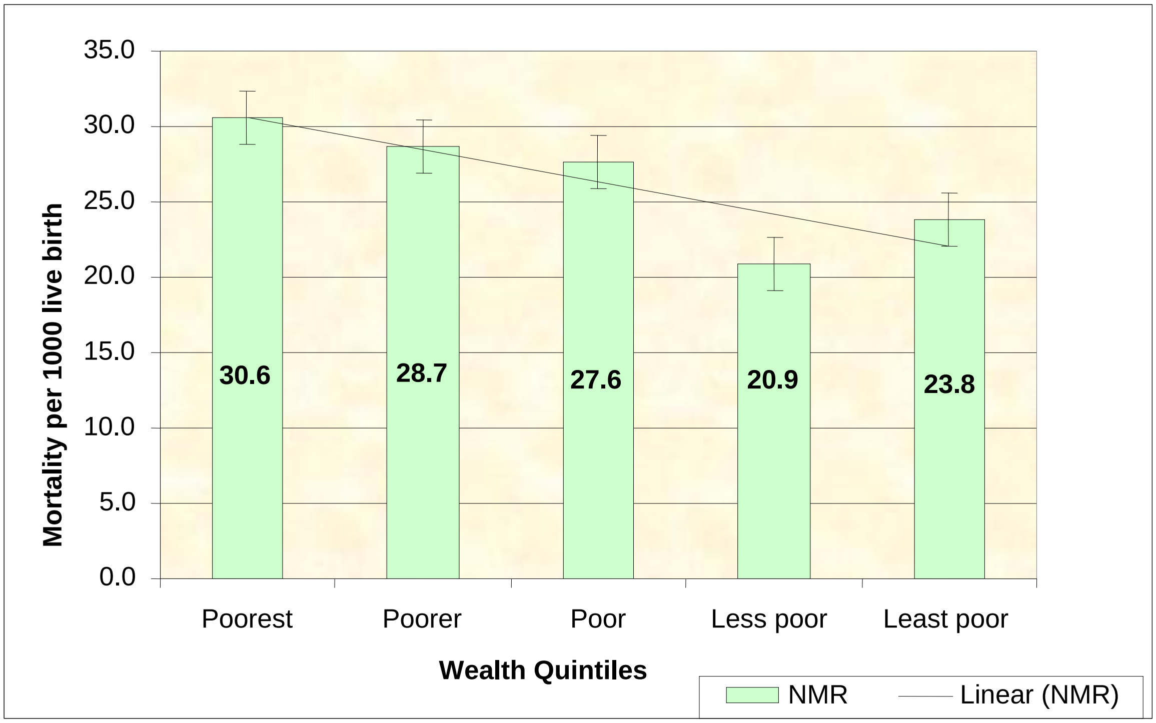

Fig 3.6 Neonatal Mortality Rates by Wealth Index in the KND between 2001 and 2005

A poorest-least poor mortality rate ratio (PPR) of 1.29 was computed which means that children in the poorest households were 29% more likely to die in the neonatal period compared to those children born in the least poor households. However, if SES of poorest households were improved to that of the least poor, then about 71 babies per 1000 live births could be saved annually. Concentration indices of -0.004, -0.008, -0.043, -0.011 and 0.0 were calculated for the different wealth quintiles respectively. The sum of these was –0.07, which is the concentration index. The negative concentration index reflects the higher mortality rates amongst poorest households. A plot of cumulative mortality by wealth index is shown in fig 3.7.

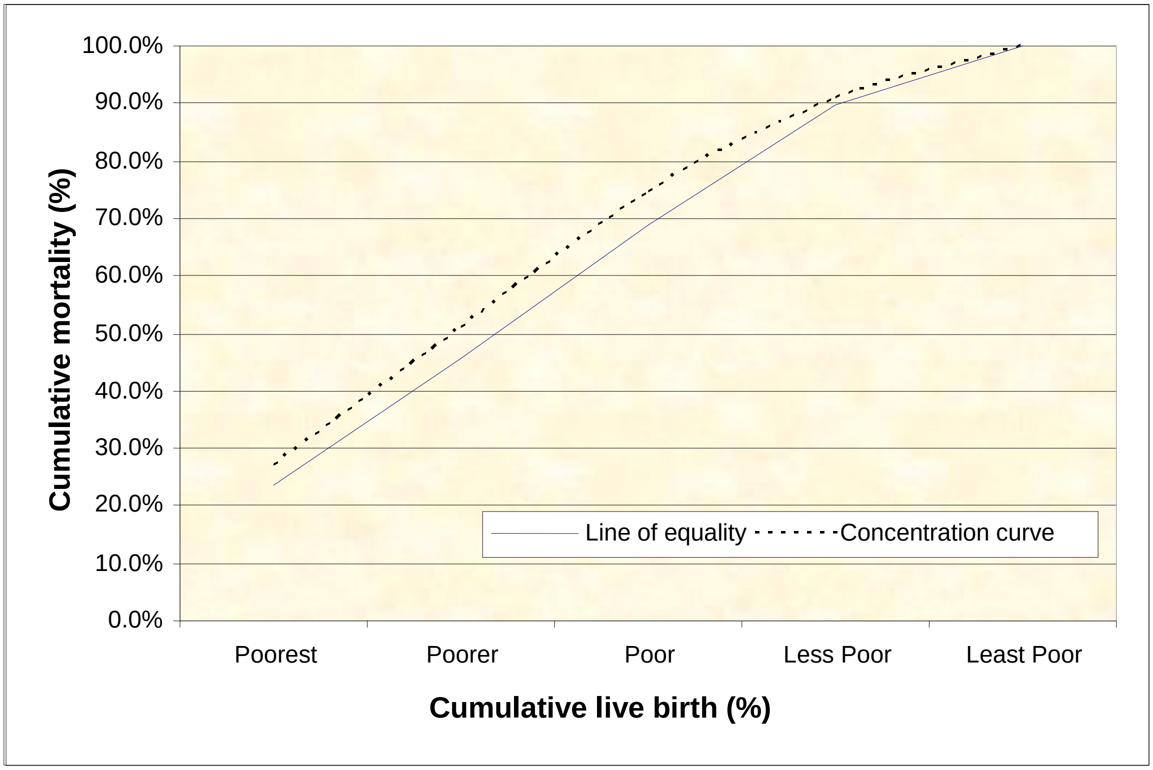

Fig 3.7 Concentration Curve of Neonatal mortality in KND between 2001 and 2005

As depicted the concentration curve lies above the line of equality showing that mortality is higher amongst the poorest households than those better off. This is reflected by the areas between the two lines.

3.5 Risk factors of neonatal mortality

Univariate logistic regression models were fitted to measure the individual effect of potential risk factor on neonatal mortality. A further multivariate model was fitted to adjust the effect of all risk factors. The results are presented in Table 3.5

Table 3.5 Univariate and Multivariate Analysis of Risk Factors of Neonatal Mortality in the KND from 2001 to 2005

Factor	Univariate (Unadjusted)			Multivariate (Adjusted)		
	OR	**(95% C.I)**	**P-value**	**AOR**	**(95% C.I)**	**P-value**
Mother's age at child birth (yrs)						
<20	**1**			1		
20-25	**0.69**	**0.53 - 0.88**	**0.004***	0.79	0.56 – 1.10	0.172
26-35	**0.49**	**0.38 - 0.62**	**0.000***	0.75	0.51 – 1.11	0.156
>35	**0.61**	**0.47 - 0.79**	**0.000***	0.92	0.57 - 1.48	0.724
Mother's education						
None	1			1		
Primary	0.98	0.76 – 1.26	0.868	0.90	0.67 – 1.20	0.459
Secondary +	0.98	0.76 – 1.27	0.888	0.82	0.58 – 1.15	0.250
Marital status						
Married	1			1		
Never married	1.20	0.93 – 1.54	0.160	1.15	0.82 – 1.61	0.431
Place of residence						
Urban	**1**			**1**		
Rural	**1.63**	**1.09 – 2.44**	**0.018***	**2.24**	**1.16 – 4.34**	**0.016***
SES (wealth index)						
Poorest	**1**			**1**		
Poorer	**0.94**	**0.72 – 1.22**	**0.631**	**0.91**	**0.69 – 1.20**	**0.508**
Poor	**0.90**	**0.69 – 1.17**	**0.433**	**0.91**	**0.69 – 1.21**	**0.523**
Less Poor	**0.68**	**0.51 – 0.91**	**0.009***	**0.70**	**0.51 – 0.96**	**0.026***
Least Poor	**0.77**	**0.54 – 1.10**	**0.155**	**0.98**	**0.62 – 1.54**	**0.941**
Child's gender						
Male	1			1		
Female	0.95	0.80 – 1.12	0.539	0.97	0.80 – 1.19	0.786
Birth order						
1	**1**			**1**		
2-3	**0.56**	**0.46 – 0.70**	**0.000***	**0.60**	**0.44 – 0.81**	**0.001***
4-5	**0.60**	**0.48 – 0.75**	**0.000***	**0.56**	**0.38 – 0.84**	**0.005***
6+	**0.66**	**0.50 – 0.87**	**0.003***	**0.50**	**0.31 – 0.81**	**0.005***
Type of birth						
Multiple	**1**			**1**		
Single	**0.24**	**0.17 – 0.33**	**0.000***	**0.20**	**0.14 - 0.28**	**0.000***

***Significant (P < 0.05)**

In the univariate analysis, the mother's age at childbirth, place of residence, SES, birth order and the type of birth had p-values less than 0.05 and indicated to have an association with neonatal mortality. For SES, all quintiles had no association with mortality except the less poor (4th) quintile. Children who died were more often to the poorest households compared to the other quintiles [AOR=0.68 C.I=0.51–0.91 P=0.009]. On the whole, SES became highly protective against mortality as it increased; except for the fifth quintile

The mother's age at child birth was significantly associated with mortality, such that children who died were more often to women less than 20 years of age compared to those born to women aged 20-25 years [Unadjusted OR=0.69 C.I=0.53-0.88 P=0.004], 26-35 years [Unadjusted OR=0.49 C.I=0.38-0.62 P<0.0001] and 35 years and above [Unadjusted OR=0.61 C.I=0.47-0.79 P<0.0001]. Maternal age became more protective against mortality as it increased from 20 years to 35 years of age; however beyond these age-groups it became less protective.

Birth order showed high association with mortality such that children who died were often from the 1st birth order compared to those children of birth orders 2-3 [Unadjusted OR=0.56 C.I=0.46-0.70 P<0.0001], 4-5 [Unadjusted OR=0.60 C.I=0.48-0.75 P<0.0001] and 6+ [Unadjusted OR=0.66 C.I=0.50-0.87 P=0.003].

Type of birth was found to be associated and highly protective to mortality such that children who died were more often from a multiple birth outcome compared to those from a single birth outcome.[Unadjusted OR=0.24 C.I=0.17-0.33 P<0.0001]. Similarly, the place of residence showed associated with mortality such that children who died were more often to women residing in the rural areas compared to those who children born to women who resided in the urban areas [Unadjusted OR=1.63 C.I=1.09-2.44 P=0.018].

3.5.1 Risk Factors of Neonatal Mortality in Kassena-Nankana District

All risk factors in the univariate models were adjusted for in the multivariate model. Maternal education, marital status and sex of the child though insignificant in the univariate analysis, were adjusted for in the multivariate model based on the fact that they were potential confounders and on evidence presented by other studies in literature on their association with child mortality.

The type of birth outcome remained a highly significant risk factor for neonatal mortality when it was controlled for maternal age at child birth, maternal education, marital status, place of residence, SES, child's gender and birth order. It was found that children who died were more often from a multiple birth outcome compared to those from a single birth outcome [AOR=0.20 C.I=0.14-0.28 P<0.0001].

For birth order, the protective effect against mortality increased as birth order increased; such that children who died more often were from the 1st birth compared to children of birth orders 2-3 [AOR =0.60 C.I=0.44-0.88 P=0.001], 4-5 [AOR =0.56 C.I=0.38-0.84 P=0.005] and 6 and above [AOR=0.50 C.I=0.31-0.81 P=0.005].

Maternal age became insignificant when all other risk factors were controlled for in the multivariate model.

For SES, it was observed that the protective effect against mortality increased as SES increased and this was observed in both the univariate and multivariate model. This observation was seen in all quintiles except the fifth quintile (least poor) which showed less protection against neonatal mortality [AOR =0.98 C.I=0.62-1.54 P=0.941]. However, when other factors were controlled for, SES remained a risk factor for neonatal mortality.

The place of residence showed an increased risk to death after controlling for maternal age, maternal education, marital status, SES, child's age birth order, live birth. Children who resided in the rural areas were 2.24 times more likely to die compared to those children to women living in urban areas [AOR =2.24 C.I=1.16-4.34 P=0.016]. Both marital status and the gender of the child remained insignificant after controlling for the other risk factors.

An adjusted multivariate model focusing only on risk factors that were significant in the univariate analysis gave similar results to the above reported results (data not shown).

CHAPTER 4 DISCUSSION

This chapter discusses the results by summarizing the main objectives of the study and the major findings according to the objectives. It also discusses the implications of the study findings with regards to health policy guidelines and concludes with the study limitations and strengths.

The main objective of this study was to examine the association between household characteristics; SES and appropriate maternal socio-demographic characteristics with neonatal mortality in the KND in Ghana from between 2001-2005. Specifically, the study aimed to calculate both neonatal mortality rates (NMR), cause-specific neonatal mortality rates (CSNMR) and to assess the relationship of posited risk factors of neonatal mortality through logistic regression analysis.

The overall NMR for the district in the five year period was low (29 deaths per 1000 live births) with infectious causes, prematurity and birth injuries being the main causes of neonatal death. This study illustrated that there was an association between SES (household characteristics) and mortality; and further illustrated an inverse relationship between mortality and increasing SES. A PPR of 1.29 showed that neonatal mortality was higher in poorest households than those better off. A CI of -0.07 indicates this inequality of mortality being more concentrated in the poorest quintile. The place of residence, SES, birth order and the type of birth outcome (single/multiple) were found to be the main predictors of mortality in the district for the study period. These study findings are similar to those of previous studies on neonatal mortality conducted in other developing countries which showed that there is a relationship between the mentioned risk factors and mortality (14-16;20;37;42;56). This study therefore provides further evidence on risk factors existing in rural settings in developing countries.

4.1 Neonatal Mortality Rates (NMR)

Neonatal mortality is a global concern mostly in the developing world. Though infant mortality rates have been decreasing steadily all over the world, changes in neonatal mortality have been much slower. Neonatal mortality rates have reduced significantly in the study district from 40.9 per 1000 live births in 1995 to 20.5 per 1000 live births in 2002. This reduction of almost 50% in neonatal mortality was observed within an eight year period in the district (14). In the five years observed by this study, neonatal mortality continued to decline with an overall reduction of 4% from 32.5 per 1000 live births in 2001 to 28.5 per 1000 live births in 2005. Not only did the study find these mortality rates lower for such a rural setting, they were much lower at a regional (SSA) and country level (for Ghana as a whole). However, these rates are consistent with those mortality rates reported by the NDSS surveys and previous studies. These low mortality rates may be due to the cumulative effect of countless health interventions conducted within the district by the NHRC and the Ghana Health Service.

These findings are acceptable as such a decline in neonatal mortality have been reported by an effectiveness study on primary health care programmes run by a non-government organization (NGO) in a rural community in Bangladesh (57). Also a 50 year study on 3 villages in Gambia reported such drastic reduction in neonatal mortality (44 to 15 per 1000 live births), infant mortality (162 to 36 per 1000 live births) and under-five mortality (397 to 66 per 1000 live births) (58). Other factors that can influence a reduction in child mortality may be the effect of increased birth intervals and improved access to health facilities. The study found a sex ratio (males/females) of 1.03 which is similar ratio to that reported by a study on risk factors for neonatal mortality in rural Burkina Faso (59), suggesting that our findings are not influenced by selection bias between the sexes. Overall, it was not conclusive as to which gender had high mortality rates due to the cross-over of rates observed throughout the study period.

4.1.1 Cause-Specific Neonatal Mortality Rates (CSNMR) by age

About 38% of babies in sub-Saharan Africa die of infections, mainly after the first week of life (60) because most births occur outside the health facilities or at home.

In our study, majority of the deaths occurred outside the health facility (65.9%) and in the early neonatal age group (0-7 days). Infectious diseases, prematurity and birth injuries were the main causes of neonatal death. Overall, all CSNMR declined; infectious diseases from 46.9% in 2003 to 24.5% in 2005, birth injuries from 35.7% in 2003 to 32.1% in 2005 and prematurity from 41.9% in 2003 to 29.0% in 2005. Our findings are consistent with findings by a study in such a setting who reported infectious diseases as the predominant cause of death in the district, and that all causes of childhood illness were declining (61).

Biological factors like gender and immunity status in a neonate can also increase the risk of dying in the neonatal period (62-64). Globally, infectious diseases remain a common cause of death in neonates (60). The immature immune systems children have at birth causes them to be more susceptible to bacterial and viral infections and at a higher risk of dying. Also infections in the mothers and poor hygiene practices during child delivery are other factors that can increase infections in newborn. For children in rural settings, the risk of death is hastened by cultural beliefs and ill practices, illiteracy, inadequate health services and poverty especially where most births occur outside a health facility.

In KND a health initiative called the Community Health Family Planning (CHFP) project deploys trained community health orderlies (CHO) to live amongst the communities and to provide basic health care services (curative and preventive) at low costs. In the study, a high number of home births were observed, with most women reporting to have been assisted by a health professional (data not shown) during child birth. This finding is rather an outcome of the CHFP program and not because mothers were unable to access health services or refused to deliver at a health facility.

The high rates of deaths from infectious diseases found by the study could be reflective of the poor living standards and nutritional status that is widespread in the study area. Lack of proper toilet facilities and clean water supply combined with little or no health care knowledge can provide routes for infections. For example a study in a similar setting in Bangladesh found toilet facility to be a predictor of neonatal and childhood mortality. They found that neonatal mortality was higher (75.2%) than post-neonatal (69.2%) and child mortality level (69.9%) in households that did not have hygienic latrines/ toilet facility compared to households who had good toilet facilities (65). Also this finding can be a reflection of the quality of health care delivered by the deployed CHOs.

Another possible explanation for these high death rates from infections may be due to the development of antimicrobial resistance from the overuse of common antibiotics in homes to manage neonatal infections (66). This overuse can result in the development of new resistant strains of virus and bacteria to common antibiotics and can lead to treatment failure and even death.

4.2 Risk Factors of Neonatal Mortality

4.2.1 Maternal socio-economic characteristics and mortality

A large number of studies have shown that maternal characteristics play an important role in child survival. In rural settings poverty increases a child's risk to death. Maternal age at childbirth, education status, SES, marital status, birth order and place of residence all have indirect association with childhood mortality. In the univariate analysis, all selected socio-economic factors had no significant associations with neonatal mortality except maternal age, place of residence, SES (measured as wealth index) and birth order.

Socio-economic status (SES)

In our study, SES was found to have an association with neonatal mortality and this remains inconsistent with two different studies conducted in the same setting using NDSS data. In both studies (67;68), SES was not a predictor of childhood mortality. Nevertheless, our findings are consistent with a study by Nathan et al in Ifakara DSS in rural Tanzania on child health inequity. They found that at infancy, children in the poorest households had a 50% higher risk of dying than children of least poor households (test for trend p=0.05). Poor maternal socioeconomic status is therefore seen as a risk factor for neonatal mortality, especially in rural Tanzania (69).

Further analysis on SES and mortality showed a positive gradient such that neonatal mortality decreased with increasing SES or living standards. A trend test on the mortality-SES gradient showed that this relationship was significant ($\chi2=8.08$ p=0.04). Socio-economic wealth inequality was measured using the PPR and the CI. Although the PPR ignores the information contained in the middle three quintiles, which is a limitation, a ratio of 1.29 showed that children in the poorest quintile were more likely to die than those in the least poor household.

A CI of -0.07 also indicates this disproportional concentration of neonatal deaths among the poor which is consistent with the PPR. Both measures gave a useful and reliable measure of health inequality in a rural setting like Navrongo, thus proving a useful method to measure health equity in similar DSS settings.

Maternal age

Maternal age at childbirth was found to not have an association to mortality, however the odds ratios (OR) obtained showed that it was protective against mortality. In the univariate, children born to women aged 26-35 years were less likely to die compared to children born to women aged 20-25 and older than 35 years. When controlled for other risk factors in the multivariate model, maternal age became insignificant and the risk of dying in the neonatal period decreased.

Contrasting results have been shown by many perinatal and under five mortality studies. These studies have shown that children born to women aged 20-34 have a lower risk of death compared to those children born to women less than 20 years and older than 34 year (70;71). Like many body functions, child bearing is a process in women that requires the body to be physically and biologically prepared to accommodate a growing fetus. Medically a woman’s body is ready for child bearing between the ages 20 years and 35 years, however if pregnancy occurs before 20 and after 35 years, the child’s chances of surviving are reduced.

Place of residence

Place of residence was found to have an association with mortality, such that children living in the rural areas had an increased risk to death compared to those children living in the urban areas (1.63 in univariate to 2.24 in multivariate model). This observation holds as women who are better educated tend to live in urbanized areas where they can easily access better health care when their children are sick and provide better living conditions which increase the chances of child survival (39). This finding is consistent with other studies in other developing countries that use the rural/urban variable as a proxy measure of living standards and have found mortality to be higher amongst rural than urban dwellers (72;73).

4.2.2 Neonatal characteristics and mortality

The child's gender had no association with mortality because both males and females almost had similar proportions of neonatal deaths.

The type of birth outcome was associated with mortality. Though multiple births had fewer observations than single birth outcomes, children born of single birth outcomes were less likely to die (76%) compared to those children born of a multiple birth outcome. Multi-fetal pregnancies resulting in twins, triplets and quadruplets are all high-risk pregnancies and births outcomes. Though they remain rare events in societies (74) these high-risk pregnancies contribute to the high rates of childhood mortality especially for newborns in the first few days of life. The association between multiple birth and infant mortality has been observed not only in developing countries (75) but also in developed countries (76;77). This study provides more evidence that children of a single birth outcome have higher chances of surviving as shown by the narrow confidence interval (14% to 28%). This is a true finding of mortality burden of singleton births. A similar conclusion was reached by a population based study in Nigeria by Uthman et al using demographic health data. Though both studies may not be comparable with regards to study design, both used population-based data. Uthman et al found that singleton births had twice reduced risk of dying than multiple births (78). Also multiple births being high-risk pregnancies and deliveries, are inherent to delivery complications that require special and expensive medical care (79).

Finally, birth order had an association with mortality, such that children of higher birth order had reduced risk of dying compared to children of first birth order. However amongst the different categories of birth order, children of birth orders 4-5 (44%) and 6+ (50%) were more protective compared to children of birth orders 2-3 (40%). Birth order was found to interrelate with maternal age and had an independent effect on mortality. These findings are consistent with other studies on birth order/parity and mortality (24;25;56;59;65;80).

4.3 Summary

Place of residence, SES, birth order and the type of birth outcome were found to be the main predictors of neonatal mortality in KND. Though few predictors were found in the area, this may have been due to the homogenous living standards spread across the DSA. In light to maximize the high coverage of ongoing health interventions in the district, investigations on the effectiveness of these programs should try to identify priority areas of so that existing health services can be strengthened or directed to addressing these priority areas.

4.4 Implications of study

The findings of this study have policy implications for stakeholders to formulate appropriate neonatal specific interventional programmes in the battle to reducing neonatal mortality in sub-Saharan Africa in general.

Firstly, more than half of the recorded neonatal deaths occurred outside the health facility and in the early neonatal age group (0-7 days). As discussed above, despite increased access to primary health care brought to homes by the CHOs, there are draw backs for such an approach. Firstly, the quality of health care provided may not be adequate or of high quality. Secondly, although it minimizes problems with regards to distance from health facilities, geographical disparity and health equity barriers existing between different socio-economic groups, this readily available health care can affect health seeking behaviours in the communities. Such that mother's may delay to bring their sick children to the community nurses for medical treatment in the early stages of illness because they feel they have access to health care readily at their own time. The delay in seeking health care is a critical factor especially in newborns in their early neonatal age group (0-7 days). This in turn means that more effort is required to educate mothers on the importance of seeking health care at the earliest time possible.

Secondly, the fact that SES was associated with mortality calls for ways to improve living standards in the district. Mortality was also found to be common amongst the poorest household in the rural areas and thus calls for further social studies to investigate why poorest households still remain disadvantaged despite easy access to health care in the district. More health campaigns directed at educating the illiterate in the poor communities will help minimize the mortality burden in poorest households.

Finally, children of higher birth order and those of a multi-fetal pregnancy had higher risks of mortality. With regards to the deployed community nurses (CHO), this calls for adequate training in midwifery skills so that they can assist in deliveries and to manage neonatal complications. This will also enable them to identify high risk pregnancies, for adequate and appropriate health care. Health education delivered to illiterate women or couples should emphasis on family planning and its importance for child survival and maternal health. Also simple health care practices when encouraged will not only save lives in this vulnerable age group but can significantly contribute to reducing the mortality burden in the district.

4.5 Limitations of study

With regards to the interpretation of our findings, the following limitations have been identified by the study;

1. **The use of demographic surveillance data:** The validity and reliability of the results are dependent on how the data was collected by the NDSS. Also this being a secondary analysis means that only variables present in the dataset could be analyzed. Other important explanatory variables or potential confounders like birth weight, distance from health facility, smoking status of mother, alcohol consumption of mother, gestation age were not captured in the dataset and so were not controlled for in the analysis.

2. **The use of the verbal autopsy:** To ascertain the probable cause of death, information on symptoms and signs are gathered from interviews with bereaved relatives. Though this method has been used in many settings to access cause-specific mortality rates, these rates are susceptible to bias and misclassification of death (81). Bias in information given on time bound variables like reporting of child's age at death must be considered given the low literacy level in the district. It is possible that their may be an under or over reporting of neonatal deaths in the dataset because the definition of live birth differs within settings. For example, in rural areas many neonatal deaths are reported as still births even when there is pulse in the umbilical cord with no movement, which by medical terms is regarded as a live birth but reported otherwise.

3. **The use of the household SES data:** The NDSS started collecting SES information for household in 2004. Children born to household that would have been abandoned or demolished before 2004 do not have SES information. However, this limitation is spread equally across both comparison groups of the study.

4. **Use of the Principal Component Analysis:** While asset-based measures are increasingly being used, there continues to be some debate about their use and more so their interpretation. These measures are more reflective of longer-run household wealth or living standards. They fail to take into account short-run or temporary interruptions, or shocks experienced by the household.

4.6 Strengths of study

The strength of the study lies in its large sample size, over 19 340 live births were analyzed hence chance findings are unlikely. Secondly, the dataset being from a longitudinal setup means that the findings can be used to generate more research questions on neonatal mortality. Finally, this study adds knowledge and information on risk factors that exist at a community level in a rural setting where proper registry systems do not exist both in Ghana and Sub Saharan Africa.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

The study found neonatal mortality rates to be relatively low in the district. During the five year period mortality rates steadily declined. Mortality cross-overs were observed between both sexes. Most deaths occurred outside the health facility mainly from infectious diseases in the neonatal period. Of all the posited risk factors shown in the conceptual framework in figure 1.1, place of residence, SES, birth order and the type of birth outcome had an association with neonatal mortality in the KND. The study also illustrated that there was an inverse relationship between SES and neonatal survivorship; such that mortality decreased with increasing SES. The early neonatal period and those children from a multiple birth outcome (twins, triplet) were identified as priority groups that require more special health care attention.

With regards to formulating health policies one should not only look at social and demographic characteristics but also factors of poverty as it plays a key role in attaining better health status. We therefore propose the following approaches which will help reduce the neonatal burden in the district;

a) Since neonatal death are common in the early neonatal period, neonatal specific interventions should pay more attention to this age group and making sure that mothers are educated on particular care practices like exclusive breast feeding, importance of body warmth for neonates and general hygiene practices that will increase survival chances of children.

b) Health education on risk factors of child mortality at a community level will not only empower mothers and encourage better treatment seeking behaviors but make them realize and understand the importance of seeking health care when their children fall sick.

c) Early initiation of antenatal care to both young and older mothers, encouraging couples to take family planning options and making them aware of risky child bearing age groups not only benefits the couples to plan their family sizes but can help reduce pregnancies in women younger (less than 20 years) and older women (35 years and above). This will also help the detection of high risk pregnancies (multi-fetal pregnancies) for appropriate referral and health care.

d) Interventions aimed at reducing neonatal mortality must incorporate programmes such as micro-financing that would improve the SES of women and their families. This is because living standards/SES was found to have a strong association with neonatal mortality.

e) Improving the quality and access of health care services received by neonates. This can be attained by ensuring that the village based birth attendants (VBA), or trained birth attendant (TBA) or the community health nurses through the CHFP program are trained adequately and with the right skills to assist in deliveries and be able to identify and seek appropriate health care when faced with neonatal complications.

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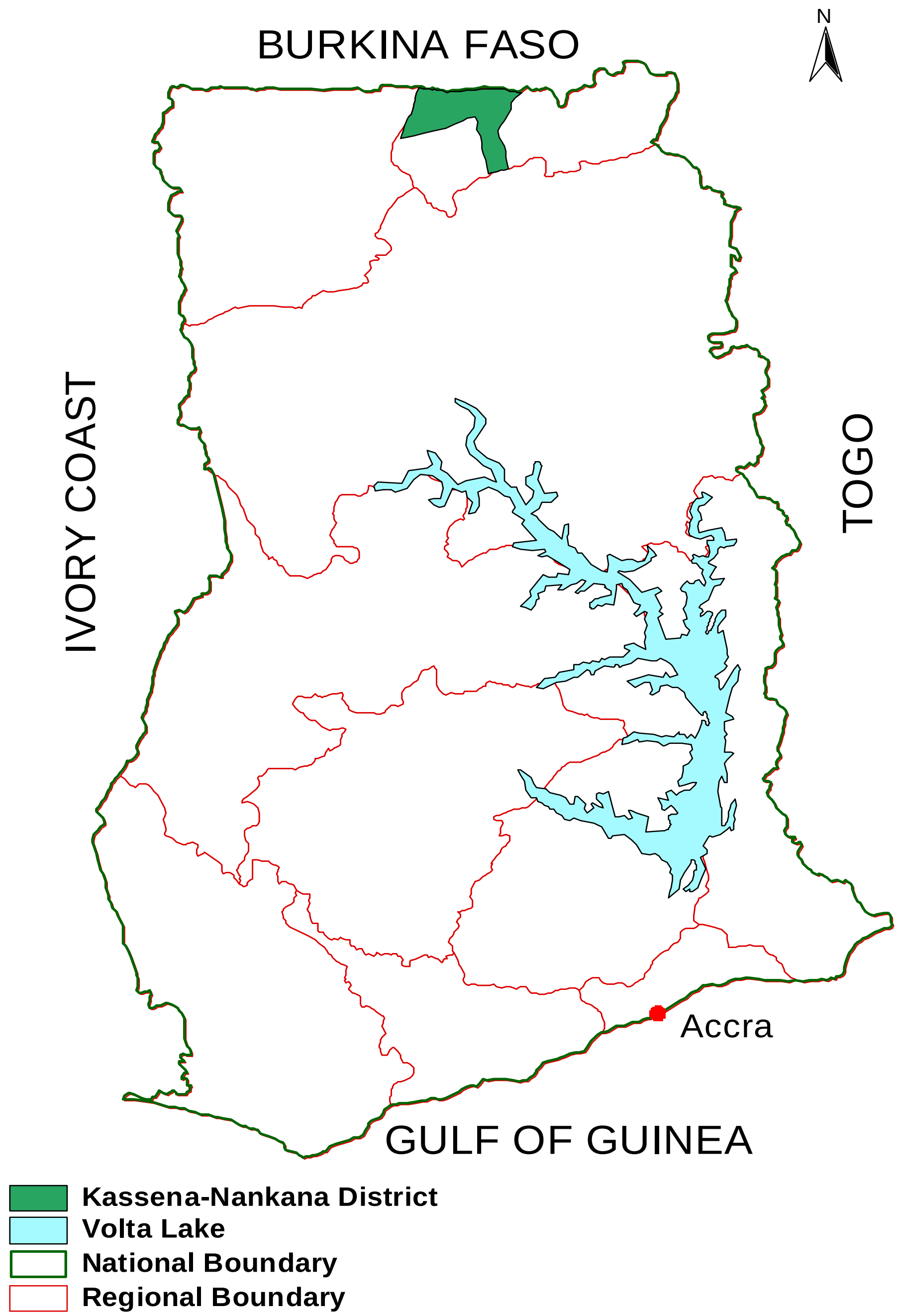
APPENDICES

APPENDIX 1: Map of Ghana showing the Kassena-Nankana District



APPENDIX 2: Human Research Ethics Clearance Certificate from the University of Witwatersrand

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Maraga

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080978**
PROJECT	Risk ~~Factors of neonatal~~ Mortality in Navrongo Demographic Surveillance Site in Ghana between 2001 and 2005
INVESTIGATORS	Miss S Maraga
DEPARTMENT	School of Public health
DATE CONSIDERED	08.09.26
DECISION OF THE COMMITTEE*	

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

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

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof KK Grobusch

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/~~We~~ fully understand the conditions under which I am/~~we are~~ authorized to carry out the abovementioned research and I/~~we~~ guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/~~we~~ undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.** 11/11/2008

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX 3: Navrongo Health Research Centre Institutional Review Board Ethics Clearance Certificate

In case of reply the number and date of this letter should be quoted.

My Ref. : app076
Your Ref:

Your Health - Our Concern

Navrongo Health Research Centre
Institutional Review Board
Ghana Health Service
P. O. Box 114
Navrongo, Ghana
Tel: +233-742-22310/80
Fax + 233-742-22320
Email: irb@navrongo.mimcom.net

10th February 2009

Miss Seri Emily Maraga
University of Witwatersrand
School of Public Health
7 York Road
Parktown 2193
South Africa

ETHICS APPROVAL ID: NHRCIRB076

Dear Miss Maraga,

Approval of a protocol titled "Risk Factors of Neonatal Mortality in Navrongo DSS in Ghana between 2001 and 2005"

I write to inform you that the NHRCIRB reviewed and approved the above-mentioned protocol.

Please note that any amendment to this approved protocol must receive ethical clearance from the NHRCIRB before its implementation.

You are also by this approval required to submit a final report of your study to the Board for review.

The Board wishes you all the best in this study.

Sincerely,

Dr. John Awoonor-Williams
Chair, NHRCIRB

Cc: Director, NHRC

APPENDIX 4: Principal Component Eigenvector Values

Asset	Frequency (n)	Poorest	Poorer	Poor	Less poor	Least Poor
Water	1090	0	0.7	2.8	17.3	79.3
Toilet	138	0	0	0	7.3	92.8
Roof	6883	5.0	12.2	23.5	34.6	24.7
Wall	1205	0	0.2	1.7	16.9	81.2
Cooking Fuel	194	0	0	4.1	19.1	76.8
Lighting	12 961	0	0.01	0.4	4.2	95.4
Land (for house)	13 936	27.9	25.3	23.0	18.0	5.9
House ownership	16 128	24.7	23.5	24.2	21.0	6.6
Bed net	13 147	22.8	22.0	23.7	21.5	10.1
Farming land	15 592	25.6	24.2	24.4	19.9	5.9
Enough Land (for food)	9 470	35.1	24.0	21.3	15.1	4.6
Enough Food	5087	40.0	20.9	18.8	14.7	5.7
Food Supplement	11 555	16.2	23.0	24.9	23.4	12.5
Enough Food to last farming season	5 377	23.5	19.6	23.2	21.3	12.4
Waste disposal	16 315	24.3	22.9	23.1	20.5	9.2
Car	260	0	0	1.5	19.6	78.9
Motorcycle	1003	0.2	1.6	3.7	32.0	62.5
Bicycle	13 416	21.9	20.7	23.7	22.6	11.0
Electricity	1198	0	0.3	0.9	3.9	94.9
Solar	188	0	0	0.5	21.8	77.7
Refrigerator	787	0	0	0.1	2.0	97.8
Television	1165	0.5	0.7	2.6	10.3	85.9
DVD/VCD/VCR	1022	0.2	1.7	8.6	17.4	72.1
Radio	12 085	19.5	19.9	24.8	23.6	12.2
Sewing Machine	3305	5.7	9.8	21.0	38.1	25.4
Stereo	5022	6.5	12.5	23.6	33.8	23.6
Iron	3556	1.7	7.5	19.5	40.9	30.4
Fan	1092	0	0	0.9	12.0	87.1
Telephone/Cell phone	712	0	0.1	0.3	15.2	84.4
Electric/Gas Stove	460	0	0	2.4	18.0	79.6
Tractor	124	2.4	8.1	7.3	39.5	42.7
Grinding Mill	177	0.6	1.1	5.7	42.9	49.7
Kerosene Stove	432	1.4	2.6	8.3	32.4	55.3
Cattle	6708	34.0	21.5	21.4	18.7	4.4
Sheep	7778	32.6	21.3	21.4	19.6	5.1
Donkey	2114	29.9	21.0	20.0	22.5	6.7
Goats	11 364	30.9	23.1	22.5	18.7	4.9
Pigs	3400	29.9	22.4	21.2	21.0	5.5