A multilevel mixed methods study of neonatal mortality in Ghana

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Abstract

Background

Reducing neonatal mortality rates [NMR] (deaths/1,000 live births within 28 days of delivery) is a key global health goal. Using comparable data from Ghana (West Africa) and Scotland, I investigated NMR, specific causes of death and risk factors in the two countries. By identifying the main causes of excess mortality in Ghana and where they occur, it is hoped more effective strategies can be developed.

Methods

This thesis used a multilevel mixed methods study design. Data on live births were obtained from three Health and Demographic Surveillance Systems (HDSS) in the north, middle and south of Ghana respectively: Navrongo (2004-12; 17,016 live births, 320 deaths); Kintampo (2005-10; 11,207 live births, 140 deaths); Dodowa (2006-14; 21,647 live births, 135 deaths). Comparable Scottish data were obtained from the Information Services Division (1992 to 2015; 1,278,846 live births, 2,783 deaths). Each dataset was analysed by neonatal death (dead/alive), using univariate and multivariable logistic regression. The multivariable analyses adjusted for maternal demographic and obstetric characteristics. Missing data were analysed using multiple imputation techniques. Data analyses were complemented by a researcher-developed questionnaire survey of 71 maternity care providers in the three regions of Ghana followed by face-to-face in-depth interviews with 48 maternity care providers who had experience of prematurity, birth asphyxia, neonatal infection and neonatal death.

Results

The NMRs in the three HDSS were: Navrongo: 18.8; Kintampo: 12.5; and Dodowa 6.2 and in Scotland it was 2.2; the NMR in both countries is reducing. More than 99% of the neonatal deaths in Scotland occurred in the first week compared to 74% in Ghana. The leading causes of neonatal deaths (NMR) in Ghana were infection (4.3), asphyxia (3.7) and prematurity (2.2). In Scotland, they were congenital malformations (0.6), asphyxia (0.4) and prematurity (0.3). Only 88 deaths (0.07) of neonatal deaths in Scotland were due to infection.

Ninety-eight percent of babies born in Scotland were born in a health facility compared to 60% of babies born in Ghana (hospital: 38.1%; clinic: 21.1%). In Ghana, babies born in hospitals had a higher risk of neonatal mortality compared to those born at home (NMR-hospital: 15.6; clinic: 7.1; home: 11.8). Most of the neonatal deaths in Ghana occurred at home (54%); there were more deaths among babies who were born in a hospital but died at home (hosp/home) compared to those born at home but died in a hospital (home/hosp). Asphyxia was the leading cause of death among hosp/hosp, and infection was the leading cause of death among hosp/home, home/home and home/hosp.

Neonatal mortality in Ghana was largely influenced by where mothers sought maternity service, or the type of personnel who provided maternity care service. Mothers and babies who were cared for in hospitals by doctors and midwives received relatively better care and proper management of birth complications. Those who were cared for in clinics received basic delivery services and management of uncomplicated asphyxia. Mothers and babies who were cared for at home by traditional birth attendants (TBA) received poor care and poor management of neonatal illnesses based on traditional approaches which increased the risk of death. Women's maternity choices were influenced by wider societal factors including prominent cultural values, family hierarchical structures and the cost of maternity services, and individual/ family factors including place of residence and availability of transport and beliefs about the cause of disease.

Conclusion

There is considerable opportunity for reducing NMR in Ghana, especially deaths due to asphyxia and infections. Most uncomplicated deliveries should be performed by midwives in community clinics. The number of community maternity clinics should gradually be increased to enable home deliveries by TBAs to be phased out. Facilities should be improved for delivery and postnatal care in hospitals and the proportion of sick babies managed by health care workers trained in their care should be increased. Regular postnatal checks in the community by trained staff should be standard.

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Dedication

In honour of all who have invested in me, most profoundly my Dad.

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I thank God for the gift of life, a curious mind and a persevering spirit. I could not have achieved this height but for His grace, and for this His praise will never depart from my lips.

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My original intent for the PhD was to investigate the risk factors for neonatal infections in Ghana. I planned on retrieveing data from patient records in selected Ghanaian health facilities. Three months down the line, JP invited her colleague, Professor Laurence Gruer, to be part of the supervisory team because of his connections to Ghana and understanding of the region. It was he who advised that retrieving patient data from hospital was not only impracticable, it was also avoidabable because there were already well established health data collection systems in Ghana. He introduced me to the Health and Demographic Surveillance Systems (HDSS) in Ghana and later he led a collaboration between the University of Glasgow and the Health Research Centres in Ghana which allowed me to access the HDSS data. It was during those meetings in Ghana that it became clearer that investigating neonatal mortality was more pressing. For willingly accepting to supervise me, travelling with me and encouraging me, I will eternally be in the debt of Prof Gruer.

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Author's declaration

This research was carried out at the Institute of Health and Wellbeing, University of Glasgow, under the supervison of Dr Daniel F. Mackay, Professor Laurence Gruer, Dr Hannah Hesselgreaves and Professor Jill Pell. This thesis comprises my original work, with the exception of the following contributions:

Chaper 4: The secondary data from the Navrongo HDSS were extracted by Paul Welaga, the data from the Kinampo HDSS were extracted by Ernest Nettey and data from the Dodowa HDSS data were extracted by Alfred Manyeh but all statistical analyses were performed by me.

Chapter 5: The data from Scottish Morbidity Record were extracted by Mark Macartney of the Information Services Division,Scotland. However, all statistical analyses with were performed by me.

Chapter 6 and 7: Oscar Bangre of the Navrongo Health Research Centre, Portia Angmorteh and Kofi Opoku Kwarteng of the University of Cape Coast translated the questionnaires and interview guide into the resepective local languages. Data collection for the questionnaire survey (Chapter 6) and in-depth interviews (Chapter 7) were assisted by research assistants who were native speakers in various regions. These research assistants also helped in the transcription and translation of the Navrongo and Dodowa interviews. However, I conducted all analyses of the interview transcripts.

I can confirm that this thesis, in its entirety, is my own original work. It has not been submitted in part or in whole to any other university for any other degree.

Shadrach Dare.

Abbreviations

AAK	Abura-Asebu Kwamankese district in the Central region
ANC	Antenatal care
aOR	Adjusted odds ratios
CHPS	Community-based Health Planning and Services
DHDSS	Dodowa Health and Demographic Surveillance System
DHRC	Dodowa health research centre
DHS	Demographic and health survey
ENC	Essential newborn care
END	Early neonatal death
FMI	Fraction of missing information
GDHS	Ghana demographic and health survey
GHS	Ghana Health Service
HCW	Health care worker
HDSS	Health and demographic surveillance system
HRC	Health research centre
ICD	International Classsification of Disease
ICE	Imputations by chained equations
INDEPTH	International Network for the Demographic Evaluation of Populations and Their Health
ISD	Information Services Department
KHDSS	Kintampo Health and Demographic Surveillance System
KHRC	Kintampo Health Research Centre
KMC	Kangaroo Mother care
KNE	Kassena Nankana East district in Navrongo
KNW	Kassena Nankana West district in Navrongo
LMICs	Low and middle-income countries
LND	Late neonatal death
MDG	Millennium development goals
MI	Multiple imputations
NHDSS	Navrongo Health and Demographic Surveillance System
NHIS	National Health Insurance Scheme
NHRC	Navrongo health research centre
NHS	National Health Service

NICE	National Institute for Health and Care Excellence
NICU	Neonatal intensive care unit
NMR	Neonatal mortality rate
NRS	National records of Scotland
OR	Odds ratios
PAC	Privacy advisory committee
PCA	Principal component analyses
PPROM	Preterm premature rupture of membranes
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
PROM	Premature rupture of membranes
SDG	Sustainable development goals
SGA	Small for gestational age
SIGN	Scottish Intercollegiate Guidelines Network
SIMD	Scottish index of multiple deprivation
SMR	Scottish morbidity Records
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SVD	Spontaneous vaginal delivery
TBA	Traditional birth attendant
UK	United Kingdom
VA	Verbal autopsy
VPM	Verbal post moterm
WHO	World Health Organization

Chapter 1 Introduction and Background

1.1 Introduction

The fourth millennium development goal (MDG) of reducing by two-thirds the global child mortality rate between 1990 and 2015 could not be achieved because of the continuing high rates of neonatal death (death of newborns within 28 days of birth) in developing countries. By the end of 2015, significant progress had been achieved in reducing the global under-five mortality rate from 91 deaths per 1,000 livebirths in 1990 to 43 per 1,000 livebirths (2). This represents a 53% reduction in the number of under-five deaths from 12.7 million in 1990 to approximately 6 million in 2015, despite population growth. Nearly half (45%) of the global under-five mortality occurred within 28 days of birth (neonatal period) and the rest occurred over a period of more than four years (3). Almost all (98%) of these neonatal deaths occurred in developing countries (4, 5). Globally, neonatal mortality rate [NMR] (deaths/1,000 live births within 28 days of delivery) fell from 36[1] in 1990 to 19 in 2015 (representing a reduction from 5.1 million deaths to 2.7 million); this translates to a NMR reduction of 63% from 8 to 3 in developed countries and a 47% decline from 40 to 21 in developing countries. In sub-Saharan Africa, NMR reduced by only 37%, which is a third less than the target, from 46 to 29 within the same period (2). With the current trend, 30 million neonates will die between 2017 and 2030 (6).

The neonatal mortality rate (NMR) is defined as the number of deaths per 1,000 live births within the first 28 days after birth. NMR is a crucial indicator for the quality of newborn care, including antenatal, intrapartum and neonatal care, and a measure of a country's overall health care system (7). The importance of neonatal mortality was underscored in the fourth MDG (8) and is again highlighted in the recent Sustainable Development Goal (SDG 3.2) which aims to "end preventable deaths of newborns" by 2030, "with all countries aiming to reduce NMR to at least as low as 12 per 1,000 live births" (9).

Although infant and under-five mortality rate in Ghana has reduced in the past 15 years, the NMR remains high and the rate of decline is inconsistent. In fact the decline in the NMR in Ghana appears to have stalled in the past five years

[1] Unless otherwise stated, all NMRs are per 1,000 live births

and currently comprises about 40% of the under-five mortality (10, 11). The NMR reduced from 42 to 27 between 1990 and 2000, but since then the rate has remained static and by 2015 it was 28 (10). This may have accounted for Ghana's inability to meet the fourth MDG. In the United Kingdom (UK), the NMR reduced from 5 in 1990 to 2 in 2015 (2). In Scotland the NMR has been less than 5 since 1974, and the current rate is similar to the UK rate (12, 13).

Most neonatal deaths in developing countries go unrecorded because of weak registration systems. Sub-Saharan Africa is among the regions with the highest NMR in the world, but its member countries have some of the weakest registration systems for health and vital events (14-16). Most newborn deaths occur at home and are unrecorded (5, 15) . There are some cultures in the sub-Saharan African region that do not consider the newborn as human until after 7 days of birth, and deaths before then not worth recording (17). Global perinatal and NMRs often do not include studies from sub-Saharan Africa because good data are lacking (15). Lack of resources in the region also stifle efforts to determine exact causes of death. NMRs are thus often estimated using complex statistical models which may not be most appropriate, hospital based studies which cannot be extrapolated to the general population or national demographic and health surveys that use cluster sampling techniques (11, 18). As a result, NMRs often tend to be underestimated. Without a clear understanding of the true burden of neonatal deaths and the causes of those deaths, planning appropriate community level interventions is extremely difficult.

Unlike most countries in the sub-Sahara African region, Ghana has three health and demographic surveillance systems (HDSS) that collect prospective data from three regions in the country (19, 20). Based in Navrongo, Kintampo and Dodowa, these ongoing surveillance systems collect primary community-based data on births, deaths, pregnancies, marriages, migration and vaccination from the northern, central and southern parts of the country respectively. These surveillance centres use a standardised neonatal verbal autopsy questionnaire to collect information and assign the most probable cause of death for neonatal deaths. These surveillance activities date back to 1992 in Navrongo, 1994 in Kintampo and 2005 in Dodowa. Thus it is possible to study and compare neonatal death rates and trends, causes of deaths and risk factors between these systems.

Epidemiological studies show that neonatal mortality is unevenly distributed across the neonatal period. Globally, mortality rates are highest within the first seven days of life, also known as the early neonatal period, and it decreases with increasing days after birth (16). About three quarters of neonatal deaths occur in the early neonatal period (21). Neonatal infection, preterm birth and low birth weight, and birth asphyxia are the leading causes of neonatal deaths worldwide (22). Birth asphyxia is mainly responsible for deaths within the early neonatal period while infection is the major cause of death in the late neonatal period (3). The distribution of the causes of neonatal deaths differ by country depending on the level of NMR. In countries with very high NMRs (NMR>45) such as Ethiopia and Nigeria, almost half of the neonatal deaths are due to sepsis, tetanus and diarrhoea. In countries with low NMR (NMR<15) deaths due to tetanus and diarrhoea are almost non-existent (5). Some studies from sub-Sahara Africa show that maternal demographics, including age and education (23) and household income (24), sex of newborn (25) are related to neonatal mortality but evidence is not conclusive (26). There is also some evidence that birth related factors such as place of delivery, order of pregnancy, multiple pregnancy, type and time of initiation of breastfeeding, and birth spacing are associated with neonatal mortality (27, 28). It is likely that infant care practices, cultural beliefs and health care seeking behaviour may also be associated with neonatal mortality (29).

Since the causes of neonatal deaths, birth and cultural practices, and availability, access and quality of health care differ by country, understanding neonatal mortality in relation to these factors in countries with high rates is crucial if effective measures are to be taken to reduce them. There is an even higher likelihood of improvement occurring if the results of such studies can be compared with other countries with low NMR (30, 31). This thesis thus seeks to investigate NMR, trends, causes of death, distribution and risk factors in Ghana and compare them with those in Scotland.

Scottish rates are selected as a benchmark because of the low NMR and availability of reliable and comprehensive data on maternal and child health. For over 30 years, the information services division (ISD) of the Scotland National Health Service (NHS, Scotland) has been collecting comprehensive routine data on all pregnancies and obstetric information, neonates, and morbidity and mortality via the Scottish Morbidity Records (SMR). As a result, it has one of the best information system on pregnancy and childbirth in the world. This is unlike England where data on some key maternal variables, for example gestation, were not collected at birth registration until about 10 years ago (12). These Scottish datasets are linked with the National Records of Scotland infant death records in what is known as the Maternity and Neonatal Linked Database (32). The Maternity and Neonatal Linked Database contains approximately 9 million records across Scotland. A catalogue of the variable lists and coding for the individual datasets in the Maternity and Neonatal Linked Database is accessible online (32). Thus, it is possible to extract information on neonate and other adverse pregnancy outcomes. Since the maternal and neonatal data from Scotland are comparable with data from the three research centres in Ghana, this study will compare them to determine the differences in NMR, assess the scale of unmet need in Ghana and potentially identify modifiable risk factors in Ghana.

1.2 From Millennium Development Goals to Sustainable Developments Goals: neonatal mortality in a global context

To reduce the high child mortality rates, world leaders at the Millennium Summit in September 2000 adopted the UN Millennium Declaration and by so doing committed to a set of eight ambitious goals, which became known as the Millennium Development Goals (MDG) http://www.un.org/millenniumgoals/. The fourth goal aimed to reduce child mortality by two-thirds by 2015, using 1990 as the baseline. It had three indicators: a) under-five mortality rate b) infant mortality rate and c) proportion of infants immunised against measles. (Unfortunately, this goal could not be achieved for reasons explained earlier) (2).

The MDGs also aimed at improving maternal health (MDG5) via two targets: to reduce maternal mortality ratio by two thirds and to achieve universal access to reproductive health. Two indicators were set to measure progress towards reducing maternal mortality: maternal mortality ratio and the proportion of births attended by skilled birth attendants. The latter indicator has been considered the ‘most relevant’ due to historical evidence of an association between skilled attendance and maternal mortality (33, 34). A skilled health personnel refers to an accredited doctor, midwife or nurse “who has been educated and trained to proficiency in the skills needed to manage uncomplicated pregnancies, childbirth and immediate postnatal period, and in the identification, management and referral of complications in women and newborns” (p.19) (35). This excludes traditional birth attendants (TBA), whether ‘trained or untrained’, or other community based care providers who have not received formal training and are independent of the health system (35). It is believed that pregnant women who receive skilled care have better newborn outcomes compared to those who are attended by unskilled providers (36). The international community, therefore, aspired to achieve at least 80% skilled attendance at birth by 2005, 85% by 2010 and 90% by 2015 (34). However by the end of 2008, only 65.7% of women received skilled care globally, and Africa- especially eastern and western- had the least proportion of skilled birth attendance, at 46.5%.

To renew its commitment to improving maternal and child health, the United Nations adopted the 17 Sustainable Development Goals (SDG) in September 2015. Unlike the previous MDGs which had few broader targets and did not explicitly mention neonatal mortality, although it could be implied. The second of 13 targets of the third SDG (SDG3) aims to: “by 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to below 12 per 1,000 live births and under-five mortality to below 25 per 1,000 live births” (9). At the current NMR, this would mean a reduction in NMR by at least a 42% in developing countries should these SDGs be achieved. In Ghana, this would mean a 57% reduction in NMR and in Nigeria and Sierra Leone 65% and 66% respectively (2, 37). Unless specific efforts targeted at reducing NMRs in developing countries are intensified and expedited, the current SDGs may not be attained.

1.3 National policy on neonatal health in Ghana

In response to the high NMR in Ghana, the Ministry of Health (MoH) and the Ghana Health Service (GHS) developed the National Newborn Health Strategy and Action Plan 2014-2018 (38). Previous policies, including the Under Five Child Health Strategy (2007-2015) (39), and the MDG Acceleration Framework and

Country Action Plan (40), had broader foci and did not give critical attention to the neonatal period. The current strategy which expires in 2018 has two main goals: a). to dramatically reduce the NMR from 32 in 2011 to 21 in 2018 b). to reduce institutional NMRs by at least 35% by 2018.

To achieve these goals, the policy sets out five major objectives:

1. Increase the proportion of health workers trained in Essential Newborn Care (ENC)
2. Improve basic Essential Newborn Care
3. Provide basic neonatal resuscitation for adverse intrapartum events (birth asphyxia)
4. Improve care of preterm or low birth weight babies
5. Improve management of neonatal infections

The details of the strategies and activities aimed at achieving the above objectives are outlined in the policy document (38). Among other things the Ghana National Newborn Health Strategy and Action Plan aim to: train at least 90% of skilled birth attendants in ENC by 2018, increase the proportion of deliveries conducted by skilled birth attendants from 68% in 2011 to 82% in 2018, increase early initiation of breastfeeding (within 1 hour of birth) from 45.9% in 2011 to 85% in 2018, reduce institutional neonatal mortality due to birth asphyxia by 50% by the year 2018, increase the percentage of preterm births under 34 weeks who will receive antenatal coritcosteroids to at least 60% by 2018, increase the number of hospitals providing Kangaroo Mother Care (KMC) by at least 80%, increase the proportion of hospitals adhering to national infection control standards, increase care-seeking for sick newborn at health facilities to at least 80% by 2018 and reduce the mortality of newborns with sepsis in hospitals by 50% by 2018.

At the current rate, it is unlikely that a ‘dramatic decline’ in NMR is possible within the last 15 months of the newborn health strategy and action plan, but there is sufficient time to work towards achieving the global goals by 2030. First this will require a clearer understanding of why Ghanaian rates are lagging behind in the road to improvement, by examining the following with regards to neonatal mortality in Ghana:

a. What? - NMR, causes of death and risk factors
b. When? - distribution of neonatal deaths and age at death
c. Where? - place of death
d. Why? - contextual factors influencing neonatal mortality

The results of these questions, and by comparing results to a country with lower NMR, will help identify areas of greatest need for interventions which will yield the greatest impact.

1.4 Aim and Objectives

The overall aim of this study is to investigate the NMR and risk factors associated with neonatal mortality in Ghana

The specific objectives of this thesis are;

1. To determine and compare NMRs and trends in three regions of Ghana and in Scotland
2. To determine the breakdown of early versus late neonatal mortality and the underlying causes of neonatal mortality in Ghana and Scotland
3. To determine the factors associated with neonatal mortality in Ghana and Scotland
4. To determine cultural and birth practices associated with neonatal mortality in Ghana.
5. To compare Ghana and Scotland in terms of overall, early and late neonatal mortality and the factors associated with neonatal mortality

1.5 Structure of thesis

This thesis essentially investigates NMR, trends, causes, risk factors in Ghana, using Scottish rates as a benchmark. It has eight chapters: the first introduces the overall research and objectives; the second reviews the relevant literature on the set objectives; the third presents the overall methodology of the thesis; chapters 4-7 present the results of four complementary studies (Table 1, p.17) which investigated different aspects of neonatal mortality or explored factors and birth practices which may influence it; and the last chapter combines all these results and discusses the findings in relation to the bigger context of maternal and child health in Ghana and the world.

The first of the four results chapters, Chapter 4, investigates the NMR and explores maternal, neonatal or delivery characteristics which may be associated with neonatal mortality in Ghana by analysing routine data on mothers and babies from the three HDSSs in northern (4.3), central (4.4) and southern (4.5) Ghana respectively. The data from the regions are compared and the similarities and differences highlighted. The reasons for major differences between them, and between the HDSSs and the national NMR estimates are explored (4.6). To provide a comparison group, Chapter 5 uses similar methods to the previous chapter to determine the NMR in Scotland and factors which may be associated with it. Given that the data available from Ghana do not include information on the clinical management of birth complications which may result in neonatal deaths, I conducted a cross-sectional survey of maternity care providers to understand their characteristics, access to equipment and knowledge and skills regarding the management of those birth complications (Chapter 6). Chapter 7 builds on the results from Chapter 6, presenting information from interviews with a sample of the care providers to understand how they managed specific birth complications and adverse newborn outcomes. A similar survey of maternity care providers in Scotland was considered unnecessary because the protocol for managing birth complications is available https://www.nice.org.uk/. The survey and interviews with maternity care providers contribute to a better understanding of the differences in NMR within Ghana, and between Ghana and Scotland. The aims of the individual results chapters, and the methods employed are summarised in Table 1. Finally, Chapter 8 summarises the key findings of the thesis, discusses the findings in Ghana and Scotland, draws conclusions and make recommendations for practice, policy and research.

Table 1: Summary of Results chapters

Chapter	Aims	Methodology	Population	Analytical methods
4	Determine and compare the NMR in three regions of Ghana Determine NMR trends Determine the distribution of neonatal deaths by time and cause of death Determine the factors associated with neonatal mortality in Ghana.	Retrospective cohort study (2004-2014)	Mothers and babies in the Navrongo (2004-12; 17,016 live births), Kintampo (2005-10; 11,207 live births) and Dodowa (2006-14; 21,647 live births) HDSS in Ghana.	Multivariable logistic regression analyses
5	Determine NMR in Scotland Determine trends in NMR Determine factors associated with NMR	Retrospective cohort study (1992-2015)	Mothers and babies delivered in public maternity units in Scotland (N=1,278,846)	Multivariable logistic regression
6	Describe characteristics of maternity care providers and types of maternity service in Ghana Describe the birth practices of the various maternity care providers in Ghana	Cross-sectional questionnaire survey	Maternity care providers in Ghana (N=71)	Descriptive statistics
7	Provide a contextual understanding of conditions in which newborns are managed Explore cultural and birth practices associated with neonatal mortality	In-depth interviews	Maternity care providers in Ghana (N=48)	Framework analyses

Chapter 2 Literature review

2.1 Introduction

This chapter summarises the current knowledge on neonatal mortality, acknowledges the strengths and limitations of the evidence and identifies the gaps in the literature. This will help place the contribution of this thesis in the context of the broader literature. The review is organised as follows:

i. Definition of neonatal mortality
ii. Neonatal mortality rate and trends
iii. Timing of neonatal deaths
iv. Causes of neonatal deaths
v. Factors influencing place of delivery
vi. Skilled birth attendance and neonatal mortality
vii. Maternal and obstetric factors associated with neonatal mortality
viii. Cultural and birth practices associated with neonatal mortality

2.2 Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was used to systematically identify and screen published literature for the rates, trends, distribution, causes of death and risk factors for neonatal mortality in sub-Saharan Africa and the UK (Fig. 2.1) (41). The following electronic databases were searched: Ovid Medline, Ovid Embase, Cinahl Plus and Web of Science. The terms used in the electronic search were: (((neonat* OR newborn OR baby) AND (mortality OR death* OR surviv*)) OR ((facility OR institution OR skill) AND (delivery* OR birth OR attend*))). These terms were adapted to suit the requirements of each electronic database. The search strategy was developed with reference to the search terms used in previous systematic reviews and in consultation with an experienced librarian. To assess the sensitivity of the search terms, key papers identified in an electronic search on Google Scholar were cross-checked with the literature retrieved in the core databases search. I also scanned the studies identified in the database search if they included seminal papers in the subject area. Critique of the observational studies included in this review was guided by the

Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and guidelines for reporting observational studies (42).

In the electronic search, studies were restricted to peer-reviewed articles published in English language. Studies were included if they were original research papers addressing at least one of the following themes; frequency, trend, distribution, causes of death and risk factors for neonatal mortality. Case reports, editorials, commentaries, clinical trials that sought to measure the effectiveness of equipment and posters were excluded. The reference lists of the identified articles were also hand searched for additional eligible literature. In the manual search, studies were excluded if they were not conducted entirely or in part in sub-Saharan Africa or UK. Studies conducted among disease populations, for example mothers with HIV/AIDS or diabetes, and those of high risk populations, for example low birthweight babies, premature babies or those with neurological conditions were excluded. Studies whose outcome was perinatal mortality, without clearly distinguishing neonatal deaths from stillbirths were also excluded.

Studies from sub-Saharan Africa were limited to those conducted from 2010 and studies from the UK were restricted to those published from 2000. There were two main reasons for limiting the African studies to post-2010. Firstly, the Millennium Development Goals (MDGs) were enacted in the year 2010. Secondly, a dozen systematic reviews and meta-analyses of studies from Africa and other developing countries on the subject have been published within the past 5 years (43-47). This demonstrates that neonatal mortality is a topical issue. To avoid duplication, I updated the most recent systematic review or meta-analysis in the relevant areas, and for themes where no systematic reviews have been published in the past seven years, I systematically reviewed the literature. Almost all the systematic reviews focused on ‘developing countries’ or ‘low and middle-income countries’ and their strict eligibility criteria excluded some key papers from Ghana. Given the heterogeneity in studies published across ‘developing countries’, this review focused on sub-Saharan Africa, with emphasis on Ghana, and comparison to studies in UK where applicable.

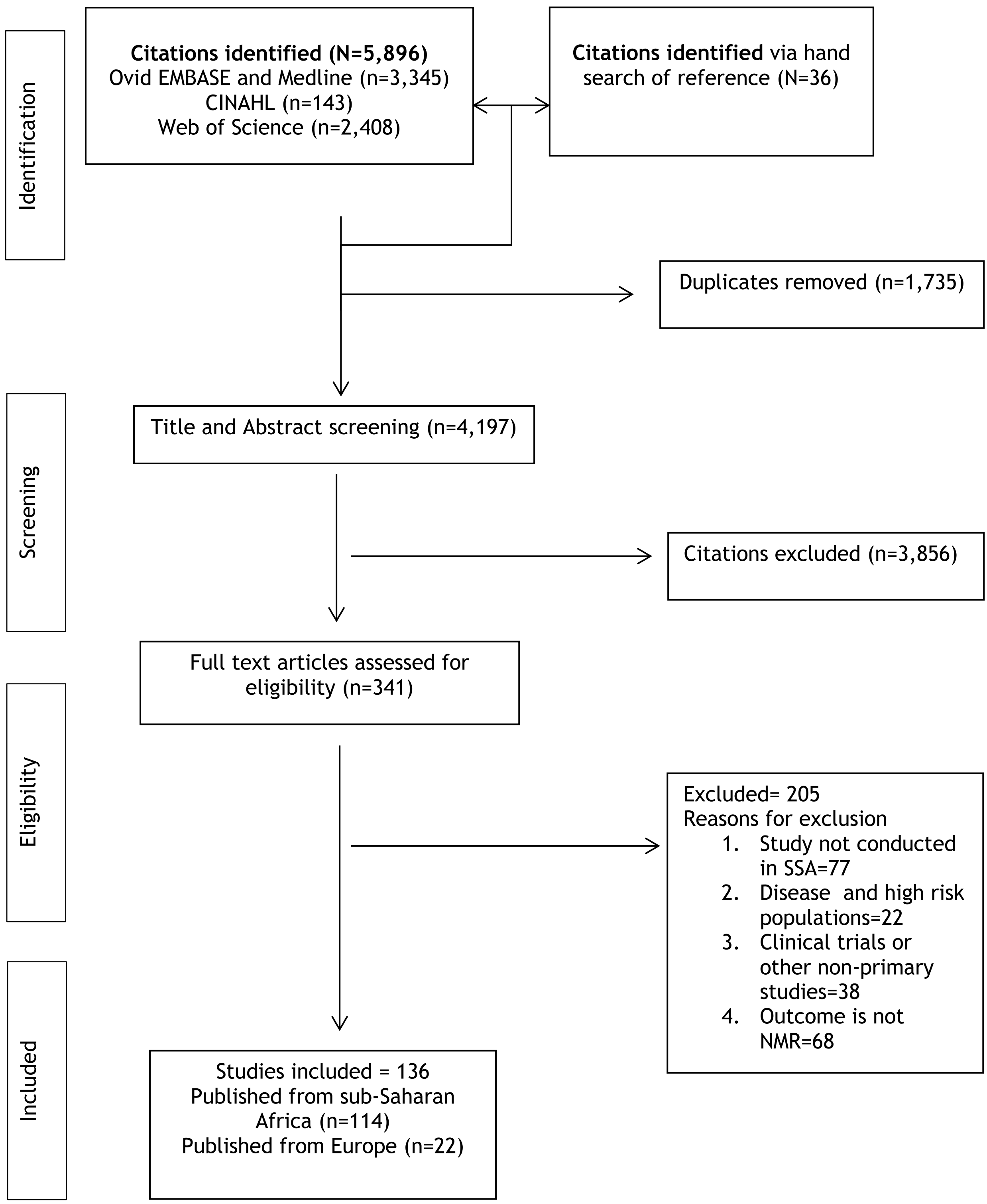


Fig 2.1: Flow of information for selection of articles

2.3 Characteristics of studies

In all, 136 studies were included in the current review; 114 were from sub-Saharan Africa, of which 36 were from Ghana, and 22 were from UK. Just a little over half of the studies (79, 58%) were cross-sectional and the remainder were prospective (n=28), reviews (n=9), confidential inquiries (n=6), or qualitative studies (n=14). The vast majority (n=116, 85%) of all the studies were community or population based.

2.4 Definition of neonatal mortality

According to the World Health Organization (WHO), neonatal mortality is the death of a newborn baby within the first 28 days (1-28 days or 0-27 days) or four weeks after birth (47, 48). Neonatal mortality rate (NMR) is thus the probability of a baby dying within 28 days after birth, expressed as deaths per 1,000 livebirths. It was not uncommon to find some studies, especially those from developed countries, to define NMR as deaths per 10,000 due to small rates (11, 49, 50). The definition of neonatal mortality has not changed over time and was largely adopted by all the studies in this review, except the demographic and health surveys (DHS) (11, 51-54).

In the DHS, neonatal mortality was defined as newborn deaths within the first month after birth. In what appears as a slight deviation from the WHO definition, 'first month' was defined as 1-30 days. Consequently deaths which occurred on the 29th and 30th day after birth were included in calculating NMR. This would, ordinarily, misclassify post-neonatal deaths and consequently overestimate neonatal mortality. However, very few deaths occurred after the 28th day. In the Ghana DHS for example, only one baby died after the 28th day in the years 1993 (n=153), 1998 (n=93) and 2003 (n= 155) and no mother reported of newborn death after the 28th day in the 2008 (n=88) and 2014 (n=160). The DHS is a retrospective survey which uses structured questionnaires to collect information on births and the health of children within the past five years preceding the survey. Information on these deaths is therefore solely dependent on maternal recall and thus approximating events which occurred in the 'past month' following birth may be the most reasonable way to aid recollection and establish some reliability of the data. This could, however, lead to clustering of events on days 7 and 30 (55) and possibly misreporting of age at death. There are also some cultures which do not count the newborn as a human until after one week or when s/he is named- and so deaths within the first week may not be reported (56). The DHS is also subject to survival bias as only mothers alive were interviewed.

It was common for the literature to classify neonatal deaths into early and late neonatal deaths, according to the age of the baby (in days) at the time of death. The WHO classifies deaths within the first week (1-7 days or 0-6 days) as early neonatal deaths (END) and those from the second to fourth week as late neonatal deaths (LND) (48). It is necessary to distinguish neonatal deaths by day of death because of the different aetiologies of early and late neonatal deaths and its implications for public health policies and strategies aimed at reducing them. The definition for early and late neonatal deaths was largely consistent between the studies included in this review, with some studies further sub-categorising early neonatal deaths into: deaths occurring on day of birth, deaths within first 3 postnatal days and deaths within 4-7 postnatal days (28, 57), but this may simply be an overemphasis especially where neonatal death is a rarity.

Perinatal mortality is a common derivative of neonatal mortality, which combines intrapartum stillbirths with early neonatal deaths, where early neonatal deaths is defined as deaths within the first seven postnatal days (48). It is argued that the similarities in the aetiology and determinants of intrapartum stillbirths and early neonatal deaths provide legitimate and logical grounds to combine them (48). Therefore, targeted interventions could be tailored for both stillbirths and neonatal deaths. Neonatal mortality, however, differs from perinatal mortality in that it focuses only on deaths among livebirths and it covers a longer period after birth. Information on livebirths is also easier to obtain and more widely available than data on stillborn babies. While there is no confusion about the definition of neonatal deaths, the disparity in defining stillbirths or early neonatal mortality between studies has implications for defining perinatal mortality. In an extreme case, one study defined perinatal mortality as the sum of neonatal mortality and intra-partum stillbirth (58). This inconsistency in defining perinatal mortality does not, in any way, raise questions about the outcome measure of this thesis which is exclusive to neonatal deaths defined as death of newborn babies within 28 days of birth (0-27 days).

2.5 Neonatal mortality rate and trends

NMR is calculated as the quotient of the number of babies who die within 28 days of birth and the total number of livebirths in a defined population, expressed as deaths per 1,000 livebirths. Ideally, this would require a register with an accurate number of all babies who were born and those who died in the given period. Such vital registers are available in developed countries (30, 50), but uncommon in developing countries (59). In developing countries such as Ghana, the DHS remain a common source of NMR for developing policies or designing programmes. The United Nations' Inter-Agency Group's report on child health, dubbed Levels and Trends in Child Mortality, is another source of NMR for international comparisons (2, 31) but it also relies on NMRs from the DHS or UNICEF's multiple cluster indicator surveys. These surveys estimate NMRs from nationally representative samples using complex statistical techniques. The limitations associated with such methods are discussed later in this thesis. There were substantial regional differences in the reported NMR across sub-Saharan Africa and within Ghana but not much difference across Europe or the UK. In both regions, the trend in NMR is reducing but the rate of reduction is much faster in Europe than in sub-Saharan Africa.

In the most recent UN report on child mortality, it was reported that at the end of 2016, the NMR in sub-Saharan Africa was 28 and in Europe it was 3 (31). These represent a 40% reduction in NMR in sub-Saharan Africa from 46 in 1990 and a 64% decline in NMR in Europe from 8 in 1990 (31). In the UK, the NMR was 3 (representing a 40% decline from 5 in 1990). A recent study also summarized the NMR, maternal mortality rate and the proportions of facility-based delivery reported in several DHS across Africa (31). It was shown that NMR across sub-Saharan Africa was wide ranging. Cape Verde and South Africa had the lowest NMR of 14.0 and 14.3 respectively, and Chad and Mali had the highest NMR of 45.8 and 45.9 respectively. In Ghana, the NMR in 2016 was 27 (representing a 36% reduction from 42 in 1990). In the Upper East region of Ghana, the NMR was 24, in Brong Ahafo region in central Ghana, it was 27, and in the Greater Accra region in the south it was 25 (10). The Ashanti region in central Ghana had the highest NMR of 42, followed by the Upper West region with NMR of 37 (10).

It is likely that the myriad of public health interventions, especially following the enactment of MDGs in 2000, including improvements in antenatal and delivery care, increased immunisation against tetanus, availability of Sulphadoxine pyrimethamine and provision of insecticide treated mosquito nets to pregnant women (60, 61) may have played a major role in the decline in NMR in sub-Saharan Africa (62-64). In Ghana for example, ANC attendance before 2000 was less than 90% but after 2000, the proportion of pregnant women who sought ANC services escalated to over 90% (92% in 2003 and 95% in 2008) (11, 51). Over the same period from 1993 to 2008, the number of pregnant women who delivered in a health facility increased from 42.2% in 1993 to 57.1% in 2008 (11, 51). This disparity in the rate of decline between the various regions in Ghana over the period requires further investigation. In the UK, declines in NMR have been attributed to invention of advanced technology for the management of intrapartum hypoxia, availability of neonatal intensive care units (NICU), increased use of surfactant and administration of corticosteroids for the treatment of prematurity (13). Similar progress was noted in other high income countries (30, 65).

The reliability of NMRs estimated from samples is highly subject to sampling and non-sampling errors. Non-sampling errors arise from the quality and completeness of information collected and sampling errors are from the representativeness of the samples. Non-sampling errors in the DHS would result in information bias, arising from misreporting of age at death and date of birth and underreporting of events. An examination of the 2003 Ghana DHS data suggested that the calendar year ratios for living and dead children were 74:76% compared with 128:135% in 2002. The authors suggested that the deficit in 2003 could be an attempt by some interviewers increasing the age of birth of children to avoid collecting further information about neonatal death or under-five mortality. This drift of children out of the five-year period will consequently lead to underreporting of neonatal mortality. It is also likely that women may refuse to report death of babies which occurred in the distant past or where babies died soon after birth, compared to deaths which occurred few years preceding the survey (66, 67). Unfortunately, the effect of non-sampling errors cannot be estimated statistically. Sampling errors from sample surveys are common because of the likelihood of obtaining different NMR with every possible sample drawn from the population (30, 65). The effect of sampling errors in a survey could be mitigated by increasing the sample size or, if resources permitted, collecting information on the entire population. Another limitation in sample estimations of NMR is its sensitivity to data quality. A rise in NMR could therefore be indicative of worsening newborn health or, in contrast, an improvement in neonatal death reportage.

2.6 Timing of neonatal deaths

In both developed and developing countries, the probability of dying within the 28 days after birth is not constant across the neonatal period. There is sufficient evidence that the risk of neonatal mortality is significantly higher in the early neonatal period, and then it attenuates across the neonatal period (5, 47). The most recent systematic review and meta-analysis showed that the majority (57%) of neonatal deaths in developing countries occurred in the first three days of life, about 78% occur in the first week of birth and the remainder died after the first week. The majority (54.5%) of these early neonatal deaths occurred on the first day (47). This systematic review included articles published up to June 2012, and only a quarter of the studies included were from sub-Saharan Africa. Other studies from Ghana and neighbouring countries confirm that the majority of newborn deaths occur in the first week of birth (28, 57, 59).

The last three consecutive DHS in Ghana have consistently reported that the proportion of babies who die in the early neonatal period is over 80% (83.1% in 2003, 85.4% in 2008 and 88% in 2014) (11, 51, 53). The DHS rely on maternal recall of events in the previous 5 years. Therefore, mothers were likely to round deaths on days 7 and 30 and consequently misclassify neonatal deaths (55). Despite its limitations, the DHS remains one of the most widely cited and perhaps the most reliable source of maternal and child health data, especially in countries without vital registers, because it uses a nationally representative sample. Other regional studies in Ghana (Kintampo and Navrongo) have shown that at least 60% of neonatal deaths occur in the first week of birth and the majority of these occur on the first day of birth (28, 57, 59). The key biological explanation given as to why a higher proportion of newborns die within the first week is poor adaptation to extra-uterine life (5). Other medical causes of neonatal death which may explain why the majority of babies die in the first week are discussed in the next section.

2.7 Causes of neonatal deaths

There is convincing evidence from global and regional studies that the leading causes of neonatal mortality are prematurity, asphyxia, infection and congenital malformations (5, 47). Asphyxia and prematurity contribute the most to early neonatal deaths, and infection is the leading cause of late neonatal deaths (47). Infection is also the leading cause of overall neonatal mortality in developing countries. A recent systematic review reported that almost all asphyxia (98%) and prematurity (83%) related deaths in developing countries occurred in the early neonatal period and a little over half (53%) of infection related deaths occurred after the first week (47). The first day of life alone contributed three quarters of the overall asphyxia related deaths and 40% of overall preterm related deaths. The distribution of neonatal deaths caused by congenital malformations was similar to those caused by prematurity.

Studies from northern Ghana suggest that the proportion of neonatal deaths caused by prematurity ranges from 5.4% - 36% (14, 57) and the proportion of deaths caused by prematurity appears to have decreased over the same period. A seven year prospective study in Navrongo found that prematurity accounted for 18% of overall neonatal mortality and 26% of early neonatal deaths (57). Earlier on, an eight year prospective study found that prematurity was responsible for 26% of overall neonatal deaths (14) and early neonatal deaths (28). Similar results were also reported in Kintampo, Ghana (59). All the studies from Ghana used a verbal autopsy questionnaire to diagnose prematurity. The gold standard for measuring gestational age is routine early ultrasound assessment together with fetal measurements (68, 69) but in many settings in Ghana, the woman’s date of last menstrual period is commonly used. The latter method assumes that conception occurs on the same day as ovulation, which is often not accurate due to variation in length of menstrual cycle (70). A previous validation study in Kintampo, Ghana found that the verbal autopsy (VA) questionnaire had 94% (95% CI: 89%- 98%) sensitivity in diagnosing prematurity in neonates (59).

Asphyxia accounted for 9.6% to 33.2% of overall neonatal mortality, 19% to 44.2% of early neonatal deaths, and 61% of deaths on the day of birth in Ghana (57, 59). The trend for the proportion of deaths caused by birth asphyxia was not regular as it swung between 9.6% and 31% in Navrongo (57) and the cause specific NMR has been constantly less than 7 over the past two decades (14). In central Ghana, birth asphyxia caused 33.2% of overall neonatal deaths and 61% of the deaths on the first day of birth (59). Clinically, asphyxia could occur at any time in the pregnancy-delivery continuum; before, during or after birth. The high proportion of neonatal deaths, particularly early neonatal deaths, attributable to birth asphyxia clearly suggests that intrapartum and delivery related complications remain a significant contributor to newborn deaths (59). A previous study which investigated the temporal relationship between obstetric events and hypoxic-ischemic encephalopathy, which is a known complication of birth asphyxia, revealed that intra partum events such as placental abruption and umbilical cord prolapse constituted the majority (56-80%) of cases, and evidence of intrapartum disturbances, such as meconium stained amniotic fluid (MSAF) were seen in up to 35% of the total cases (71). Given that the majority of birth asphyxia occurs during the intrapartum period, it is plausible to assume that unsupervised deliveries or deliveries conducted by unskilled personnel may be a significant risk factor for asphyxia related neonatal deaths. The skillset of maternity care providers- in hospital and community settings- in the management of asphyxiated babies is subject for further investigation.

In Ghana, the proportion of all neonatal deaths caused by infections range from 18.2% to 51.2% and the proportion of late neonatal deaths caused by infections were over 50%. The trends in the proportion of deaths caused by infections have remained constant. A previous cross-sectional study in central Ghana found that infections contributed 40.3% to all neonatal deaths. Infections were related to 24.5% of early neonatal deaths and 84.3% of late neonatal deaths (59). Similar findings were reported previously in two prospective studies in the Kassena Nankana district in northern Ghana, where infections caused 39.2% and 32% of neonatal deaths between 1995- 2002 and 2003- 2009 respectively (14, 57). In these studies, the proportions of late neonatal deaths caused by infections were 66% and 59% respectively. Edmond (59) reported that the common infections in Kintampo, central Ghana, as diagnosed by the VA tool, were septicaemia

(15.6%), pneumonia (4.6%), meningitis (3.4%), diarrhoea and tetanus. Another study in northern Ghana reported that the common infections were septicaemia (86.9%), acute lower respiratory infections (5.8%), meningitis (5.1%), anaemia (1.5%) and diarrhoea (0.7%) (57).. It could thus be deduced that most of these infections are bacterial, although the diarrheal diseases could also be viral. Unfortunately, the verbal autopsy questionnaire which was used to diagnose these infections is not designed to identify the exact causative organisms.

It is not clear what factors could be driving these proportions of the causes of neonatal death. Some studies suggest that the setting where delivery is conducted and access to a skilled birth attendant may be related to the proportions of neonatal infections and asphyxia (57). In the previous cross-sectional study in Kintampo, although there was no significant difference between early, late and overall neonatal deaths which occurred in health facility or at home (50.9% versus 49.1% respectively), there was a significantly higher proportion of home-based deaths from infections (49.6% versus 31.0%) and higher rates of birth asphyxia (20.8% versus 44.8%) related neonatal deaths in the health facility (59). There were almost equal proportions of premature deaths in the health facility and the home (18.6 versus 21.8% respectively). The higher proportion of facility-based deaths related to birth asphyxia and injury could be because of the increased likelihood that complicated births could be delivered in the health facility or overuse of instruments (72, 73). On the contrary, the increased proportion of deaths related to infectious diseases could be due to poor postnatal care at home. Only 59 (20.7%) of the women who reported home-based neonatal deaths in that study sought some form of medical care during the period of sickness preceding the death of the neonate (59). These results however, are less informative, with respect to the influence of delivery site on infection related neonatal mortality, as the authors did not report on deaths by site of delivery.

2.8 Traditional birth attendants in Ghana

Traditional birth attendants (TBAs), home birth attendants or unskilled birth attendants are synonyms that refer to a group of maternity care providers who have received very little or no formal training. According to the WHO, a TBA is "a person who assists a mother during childbirth and who initially acquired her skills by delivering babies herself or through apprenticeship to other TBAs" (74). TBAs are in contrast to skilled birth attendants, defined as doctors, midwifes, nurses or community nurses, who have received appropriate formal training (didactic and practical) and accreditation to provide maternity services (35). TBAs are common in developing countries because universal access to skilled care is not available. In these countries, TBAs provide home-based or out-of-facility maternity services, including antenatal services, delivery and child care services. Most TBAs do not receive financial remuneration for their services, but they may receive goods (food or clothes) and services (support with domestic activities) from her clients (75). In developed countries, however, TBAs are no longer in practice and home based deliveries are delivered by skilled personnel. In the UK, for example, maternity services by uncertified and untrained midwives, also known as handywomen, have been outlawed for at least a century (76).

The typical TBA is a female, over 40 years of age, a mother, and a member of the community in which she works and maybe selected by that community to assist in childbirth (75, 77). Several studies in Africa found they have poorer skillset compared to their skilled counterparts, including infection prevention practices and management of birth complications (56, 78-84)- (See Section 2.12). A recent large multi-site survey of home birth attendants (n= 1,226) showed that only 30% were literate; they were generally older (median age= 53 years); 87% had not had more than one month of formal training; only 19% had access to motorised transportation, and most home birth attendants did not have basic equipment including blood pressure apparatus, stethoscope, infant bag and mask manual resuscitator (77). Yet they are often highly regarded and highly sought after in the communities they serve because of the social, spiritual, cultural and psychological support they provide for women in labour (Details discussed under Section 2.12) (85-87), compared to midwives who have been known to be rude to women in labour (88, 89). While TBAs score less on the technical aspects of care, they are well known for their cultural understanding and empathetic approach to care provision.

In Ghana, like other developing countries, there have been attempts since the 1970s to formalise the activities of TBAs or improve their skills through some form of training (90, 91). It was suggested that given the high maternal and perinatal mortality rates and the proportion of births attended by unskilled providers, training TBAs could improve maternal and child outcomes (83, 92, 93). The value of their training today is controversial and there are some who argue that TBAs act as ‘stopgaps’ by delaying the initiation of more impactful activities, and their typically low caseloads do not justify the cost of their training (94). A meta-analysis of the effect of TBA training on the knowledge and attitude of TBAs found significant improvements, but ongoing supervision and integration into formal health care systems may be required to ensure that the acquired knowledge is translated into practice. Empirical evidence of the effectiveness of TBA training on maternal and neonatal outcomes is also not compelling (95, 96). The quality of the papers included in the meta-analysis also did not allow the authors to conclude whether TBA training was causally linked to neonatal outcomes (96). Further questions about the cost-effectiveness of TBA training remain unanswered. There have been calls in some parts of Ghana to ban maternity services by TBAs but Kruske & Barclay (75) warn that such policies risk ignoring the invaluable sociocultural roles TBAs play in their local communities as well as the difficulties of providing universal skilled care in rural non-Western areas.

Given that home deliveries in developing countries are synonymous with unskilled maternity care and facility based care is similar to care by skilled personnel, researchers investigating the effects of the type of maternity care provider on neonatal mortality use the delivery care setting as proxy. Details of the association between type of maternity care provider and neonatal mortality are discussed in the next Section 2.10.

2.9 Factors influencing place of delivery

“Skilled care at every birth” remains a widely promoted concept by many international health organisations, including WHO, because it is believed that institutional deliveries are associated with quality maternity services, which could then improve neonatal survival. Three main components of skilled birth attendance are recognized: i) the presence of an accredited health provider, ii) an enabling environment and iii) a viable referral system (35). An accredited health provider is defined as one of the following trained personnel: doctor, midwife, nurse or community nurse. The first two components are commonly explored in academic research but all three components are yet to be combined into a single variable to determine their overall effect on neonatal mortality. In developing countries, institutional delivery is synonymous with skilled birth attendance and home deliveries are more likely to be delivered by ‘unskilled’ personnel (10, 11). This is unlike developed countries where over 99% of deliveries occur in accredited health facilities and home deliveries are also conducted by skilled personnel (97). This may explain why I could not identify any study which exclusively explored the relationship between skilled birth attendance and neonatal mortality in developed countries. This review shows that the proportions of institutional delivery in sub-Saharan Africa are wide ranging and the rates have increased over time but the relationship between institutional deliveries and neonatal mortality remains unclear.

Primary studies included in this review found a wide variation in the proportions of institutional delivery across sub-Saharan Africa and within Ghana. Moyer (98) summarized the proportions of health facility utilization and NMR from the DHS across 36 countries in sub-Saharan Africa. It was shown that institutional delivery ranged from as low as 9.9% in Ethiopia in 2011 to 84.7% in Gabon in 2000. In Ghana, the 2014 DHS showed that overall 73% of mothers who delivered in the 5 years preceding the survey delivered in a health facility. This represents a 24% increment from 55.5% in 2008 (11, 44). There was also wide regional variation in institutional delivery in Ghana, from 35.4% in the Northern region to 92.5% in the Greater Accra region. This shows that although skilled birth attendance in Ghana has increased over the years, the rate of increase appears to be slow and the coverage is uneven.

Ethnographic studies in rural Ghana show that most women preferred to deliver at home because it was deemed prestigious and it increased women’s status (99). In these communities, only ‘lucky’ women experienced easy labour or ‘talented’ women could deliver at home. In contrast, seeking skilled attendance decreased a woman’s status in the community. Hospital delivery was a sign of a difficult delivery and women who underwent caesarean sections were considered as ‘less fortunate’. Justifying home deliveries, other TBAs indicated that pregnancy is not a disease which warranted hospitalisation; it is natural and women can deliver at home (100). In these communities, it was believed that insincerity about the paternity of the baby and immodest maternal behaviour caused difficult delivery. Similar beliefs have been reported in Zambia (78). Poor attitudes among maternity care providers and expensive birth items demanded of women for facility-based deliveries, the need for a support person during facility delivery and lack of transportation also deterred most women from seeking facility-based delivery in these rural communities (99, 101, 102).

The proportions of institutional deliveries also differ by maternal sociodemographic characteristics and place of residence. In sub-Saharan Africa, the proportion of institutional delivery has been found to increase with the mother's and her partner's education, primiparity, household wealth (103) and urban residence (104). In addition to the above, studies in Ghana show that Christianity, monogamy, antenatal care attendance, old age at first birth and health insurance coverage are associated with institutional delivery (10, 44, 81, 101, 105). The institutional delivery rate among women in urban regions in developing countries was reported to be about 75% compared with 36% in rural regions (106). Multivariate analyses of the 2008 GDHS showed that the most important factors that drove institutional delivery were affordability and accessibility (geographic and social) (107). Affordability, measured as household wealth index (aOR 2.3, 95% CI 2.0-2.7) and having health insurance (aOR 2.7, 95% CI 1.8-4.2), doubled a mother's likelihood for institutional delivery. In terms of accessibility, urban residence was associated with a higher likelihood of delivering in a health facility.

In terms of social access, it was found that needing permission to go to a health facility and lack of involvement in the final decision regarding health care were significantly associated with low institutional delivery (107). Similar findings have been reported in recent studies (100, 108-112). In these studies, the decision regarding where women sought delivery services was dictated by older family relations, in-laws, their spouses or family heads. It is plausible that lack of maternal autonomy in obstetric decision-making is a reflection of maternal literacy, health insurance coverage and household wealth. Mothers who need permission to attend delivery services may also require permission to acquire health insurance or employment, and are more likely to be less educated (107, 113). In Tanzania, agreement between a woman and her partner regarding the importance of facility delivery was associated with a two times chance of delivering in a facility (112). Where there was disagreement in the choice of place of delivery between partners, the view of the woman was upheld (112). Agreement between partners and male involvement have also been shown to promote positive attitudes in antenatal care acceptance, breastfeeding and abortion care (114-118). It is important to note that the distribution of power between partners may also be influenced by other social and demographic factors such as wealth and education (119, 120). The apparent lack of women's autonomy in making decisions about her health could be a part of a larger fabric of gender inequality and economic marginalisation and so programmes aimed at creating an egalitarian society, including female education, women empowerment and economic independence, may in the long term improve maternal and child outcomes.

The dynamics of decision-making power within each household may be a reflection of the differences in cultural systems of inheritance or kinship (121). In northern Ghana, which is mostly patrilineal, it was reported that compound heads, who were often grandfathers or husbands, had to "give the order" for women to seek maternity services (108, 122). The impact of grandmothers or mothers-in-law in this region was not as commonly reported as in central and southern Ghana (99, 100) where the system of inheritance among most southern tribes is matrilineal. The lack of decision-making power among women was also exacerbated in Islamic homes where religious beliefs dictate that men were heads, polygamous homes and among rural women (110, 111). Whether matrilineal or patrilineal, Muslim or African traditional religion, the lack of maternal autonomy in making decisions about her own health is concerning and has important policy implications. Given the cultural and ethnic diversity in Ghana, it is important to understand the dynamics of maternal autonomy across different cultures.

2.10 Skilled birth attendance and neonatal mortality

Two systematic reviews, one global and the other regional, have explored the association between facility-based delivery and neonatal mortality within the past five years (43, 98). The results from these reviews suggest that facility-based deliveries do not decrease NMRs, but the findings are inconclusive. The systematic review in sub-Saharan Africa (98) found that the utilisation of facility-based deliveries was higher in southern Africa (54%) and lowest in central Africa (27%). Facility-based deliveries were not correlated with early neonatal mortality in either of the regions and overall (r=-0.40, p=0.08). In another meta-analysis, 10 out of 19 studies from low and middle-income countries found that institutional deliveries were protective of neonatal mortality and the remainder found no association (43). Although overall, institutional delivery conferred protection for neonatal mortality (RR 0.71, 95% CI 0.54-0.87), when these studies are stratified by region, 50% (4 out of 8) of those from sub-Saharan Africa, mostly cross-sectional studies, found a significant association and the remainder, mostly prospective studies, found no association.

There is some evidence from primary studies of an overall negative relationship between institutional delivery and neonatal mortality, but the results are conflicting. Some studies have found institutional deliveries are protective of neonatal mortality (43, 44, 123), but others have found no association (57, 124). The results in these studies also differ depending on the country, type of study and how institutional delivery was measured. Ecological studies show an inverse relationship between the proportions of facility-based delivery and NMR (44, 98, 106). Analyses of 36 DHS in sub-Saharan Africa, for example, found a negative relationship between the proportions of facility-based deliveries and neonatal mortality (44). Countries with higher proportions of facility-based delivery had lower neonatal morality rates, particularly late neonatal mortality. Institutions with over 60% utilisation rates were protective of early neonatal mortality and those under 60% were significant risk for mortality (106). Unfortunately, the possibility of an ecological fallacy, which assumes that all women in countries or facilities with higher institutional delivery rates have better neonatal outcomes than those in settings with lower rates, cannot be ignored and some of these studies were simply descriptive without adjusting for possible confounding variables (44). In contrast, a recent robust study by Fink et al., (2015) (106) which analysed results from 192 DHS from 67 developing countries (*n*=1,473,226) found no association between institutional delivery and early neonatal mortality overall (adjOR 1.00, 95% CI 0.97-1.03) or in public facilities. When stratified by country, the study found that giving birth in a health facility was protective of early neonatal mortality in only eight out of 32 (25%) countries from sub-Saharan Africa. The majority (63%) of sub-Saharan African countries found no association and four (13%) found institutional delivery to be a significant risk factor for early neonatal deaths. In Ghana, a multivariable analysis of the 2008 Ghana DHS found that skilled personnel at delivery was not significantly associated with neonatal mortality (124).

Given that deliveries in health facilities are more likely to be by trained and qualified personnel and deliveries at home are conducted by untrained personnel, two possible reasons may explain why institutional deliveries may not be related to neonatal mortality. First, worst outcomes in health institutions raise questions about the quality of health facilities and newborn care services. A comprehensive assessment of healthcare facilities in the Brong Ahafo region of Ghana noted 'a large quality gap' for maternity services (125). The authors observed a low quality of intrapartum and postnatal care and a low proportion of effective coverage of skilled attendance. Another study in the same region reported that midwives were not trained in essential newborn care and only 33% of babies were born in faciliies capable of providing high quality basic resuscitation (126). On the other hand, it is possible that the visible effect of institutional delivery in these studies were affected by self-selection of complicated obstetric cases into health facilities or the transfer of worse cases to the hospitals. Alternatively, low risk mothers preferred to deliver at home. As a consequence, neonatal outcomes for babies born in health institutions will be worse, even if the level of care provided was standard. In the previous analyses of 192 DHS, the authors observed significant protective effects of institutional deliveries after correcting for probable differences in high risk deliveries in health facilities (aOR 0.88, 95% CI 0.81-0.96), measured by past medical need. Future studies which explore the differences in services provided in health institutions and homes, the quality of these services, or the characteristics of patients in both facilities will provide clearer explanations.

The majority of studies investigating the effects or associations of place of delivery on neonatal mortality categorise place of delivery into facility-based delivery and home deliveries. While a dichotomy of delivery place is simple, it overlooks the differences in types of facilities- hospital, clinic or community-based health planning service (CHPS)- or the size of the facility which may also be an indication of the quality of services provided or the type of personnel (43, 98, 106). In addition, information on place of delivery and neonatal deaths were mostly self-reported. Underreporting of home deliveries or systematic misclassification of institutional deliveries may therefore have affected the results. Lastly, pooling estimates for countries under the umbrella of 'developing countries' or 'low and middle-income countries' overshadows country specific relationships (106). Health care systems are highly variable across and within countries, and the care of babies is very much influenced by cultures, which are highly heterogeneous. Studies which consider more culturally homogenous populations or take into account the cultural differences between countries and regions, although laborious, are recommended.

2.11 Maternal and obstetric factors associated with neonatal mortality

For the purpose of this review, the commonly reported risks of neonatal mortality are categorised into maternal (age, socioeconomic status, education, parity and occupation), neonatal (sex, birth order and birthweight) and obstetric factors (multiple births and birth interval).

There is some evidence that the age, parity and the socioeconomic status of the mother may be associated with neonatal mortality, but the evidence regarding the relationship between maternal education, place of residence, occupation and neonatal mortality is conflicting. Two recent meta-analyses showed that nulliparity and being aged <18 years are associated with an increased risk of adverse neonatal outcome (45, 127). Compared to mothers aged 18 to <35 years with up to 2 children (parity 1-2/age 18-<35), all mothers of the other parity/age exposure groups (nulliparous/ age <18 years, nulliparous/age 18-<35, parity >=3/age 18-<35 and, parity >=3/age 18>=35) had significantly increased risk for neonatal mortality, and nulliparous/age <18 years had the greatest risk (adjusted OR 2.07, 95% CI 1.69-2.54). Nulliparous mothers who were less than 18 years were also at increased risk of small for gestational age (SGA) and preterm birth. The meta-analysis was restricted to only cohort studies in low and middle-income countries (LMICs) and none of the studies was from Ghana. A previous study showed that adolescent mothers were more likely to have high risk behaviours compared to adults (127): single parents, multiple partners ($p<0.001$) and not going to school ($p<0.001$). It has been suggested that the socioeconomic disadvantages of teenage mothers may have increased adverse birthing experiences and outcomes.

Few studies in Ghana have identified maternal teenagehood and advanced maternal age, defined as aged over 40 years, to be significantly associated with neonatal mortality (124, 128), but some results are inconclusive (57) and others are conflicting (27). A secondary analysis of a combined dataset of 5 DHS from 1996 to 1998 in 5 West African countries (including the 1998 Ghana DHS), found that compared to women aged between 20-39 years, teenage mothers and mothers aged >40 years were at higher risk of neonatal mortality (128). Teenage mothers had a 19% and mothers >40 years had 31% increased risk for neonatal mortality (128), but the relationship for teenage mothers was not significant at 5% standard error. The authors used a Cox-regression analysis which accounted for differences between countries (128). Secondary analyses of the 2008 DHS observed that a unit rise in maternal age was significantly associated with a 2% increased risk for neonatal mortality (124) but an analysis of the combined 2003 and 2008 datasets did not find any significant results (27). Important confounding variables are likely to be less accurate in cross-sectional studies than those in prospective studies. For example, cross-sectional studies largely depend on maternal recall for variables such as gestation (57), which is likely to be less accurate than prospective studies which follow mothers from pregnancy through to birth. In addition, variables such as socioeconomic status recorded at the time of interview in cross-sectional studies are also likely not to reflect the true condition of the mother during pregnancy. More prospective studies investigating the association between maternal factors and neonatal are recommended (57).

Studies reporting on the association between socioeconomic status and neonatal mortality in Ghana suggest an inverse relationship. That is, the higher a woman's socioeconomic status, the lower the risk for neonatal mortality (27, 124). A recent longitudinal study by Welaga et al., (2013) (57) however did not find any relationship between a woman's socioeconomic status and risk for neonatal mortality. It is important to note that the former two studies used DHS data which comprise both rural and urban residence (27, 124) and the latter study by Welaga was based in the Kassena-Nankana district which is largely rural (57). It is likely that socioeconomic status was not related to neonatal mortality in the latter study because of the widespread of Community-based Health Planning and Services (CHPS) in the district (62). The CHPS programme is an initiative of the Navrongo Health Research Centre, and subsequently adopted nationwide by the Ghana Health Service, which assigns nurses to community health centres to make health care easily accessible to community members. The Kassena-Nankana District also falls under the Navrongo HDSS, which is a popular place for many clinical trials and health education initiatives, and thus the people in the region may be more health conscious than the rest of Ghana (14, 19). It is therefore plausible that improvements in health care access and consciousness may have offset the detrimental effects of poverty on neonatal health (64).

The biggest challenge with investigating the socioeconomic effects on health outcomes is, arguably, how to accurately measure socioeconomic status, and a wide range of options have been suggested (129). In the studies reviewed above, socioeconomic classifications were based on household ownership of consumer items like bicycle, car and television and characteristics of dwelling place including sanitation facilities, type of flooring material and source of drinking water (11, 14, 19, 57). While asset-based measurements appear rational and simple (130, 131), they do not necessarily demonstrate expenditure (132). There is also a particular problem with ascertaining asset quality as the inclusion of mal- or non-functioning assets could give a false impression. For example, a household may indicate ownership of a refrigerator but it may be non-functioning. The DHS also simplistically measures car ownership but does not distinguish between a saloon car and a four-wheel drive or the age of the vehicle. The use of asset-based measurements has also been found to be urban-biased because the items assessed capture social stratification better in urban than rural settings (133). Rural dwellers with no access to electricity or pipe borne water are unlikely to have televisions or refrigerators but may own large farm lands and livestock which urban dwellers could not boast of. On the other hand, owning a television in the city may not be a sign of wealth. Therefore this classification which uses items common in urban settings is most likely to misclassify rich households who live in rural areas and a large proportion of urban households are likely to be assigned higher wealth-scores. In the DHS for instance, about 74% of the urban population were in the highest two quartiles compared to only 14% of the rural population (11). It is thus possible for the observed association between socioeconomic status and neonatal mortality in the studies using national data to be driven by rural-urban differences (128).

Education and occupation are often used in epidemiological studies as proxies for socioeconomic status. They could be combined as a composite or a derivative for individual socioeconomic status (124), or they could be treated independently (57, 128). With reference to perinatal and neonatal studies, maternal education and occupation are preferred. Most studies included in this review, cross-sectional and longitudinal studies alike, did not find a significant association between a mother's highest level of educational attainment and risk of neonatal mortality. In some studies, higher education appeared to confer some protective effect against neonatal deaths, although the results were not significant (57, 124). This was surprising because education has been shown to contribute to positive health via a myriad of pathways. The drastic reduction in child mortality observed between the 1970s and 2009, for example, had been attributed to increases in educational attainment of women in their reproductive years (134). All the studies in this review measured education as the highest level of formal education completed without taking into account women who learned a vocation. It may thus be more accurate to state that there was no association between highest level of formal education attained and neonatal mortality in Ghana. Maternal occupation, on the other hand, appeared to be related to neonatal mortality, but the results were not statistically significant (27). Compared to unemployed women, manual workers had higher odds for neonatal mortality (OR: 1.24; 0.56-2.74) and white collar workers had reduced odds for neonatal mortality (OR: 0.79; 0.34- 1.81).

The three most important neonatal factors reported to be associated with neonatal mortality in Ghana are; sex of the baby, birth order and birthweight. There is convincing evidence that first born babies are about two times higher risk of neonatal deaths (57, 128) or early neonatal death (adjusted OR: 1.75; 95% CI: 1.28-2.40) (28), compared to second to fourth born children. And there is some indication that the risk of neonatal deaths decreases with increasing birth order (27), but the risk of death is not significant after the fourth born (57, 128). There is evidence that the risk of mortality is higher among males than females in the neonatal period but results are not significant (14, 27, 124, 135). All the studies in this review had significantly large sample sizes ($n \geq 10,000$) and thus the results are unlikely to be spurious. Male babies have long been known to be at higher risk of death than girls, in what has been documented as the 'male disadvantage' (136-139). The biological mechanism underlying the excess mortality among boys is not fully understood and some authors suggest a delay in lung maturation (140, 141) and a higher rate of SGA among boys (142) may be contributing factors. Prematurity and low birth weight is one of the three important 'causes' of neonatal mortality in developing countries, and many studies in Ghana have found the same (5, 57, 59). Babies with low birthweight (<2.5kg) were reported to be twice at risk (OR: 2.01, 95% CI: 1.23- 3.29, $p<0.001$) for neonatal mortality compared to normal weight babies (≥ 2.5kg) (27). In this study, birthweight was retrieved from both health records as well as maternal recall. Previous studies have found that six to sixteen years parental recall of child birth weight is still reliable (143, 144).

Many studies have found that twin birth is a significant risk factor for neonatal mortality (28, 57, 128). Compared to babies of singleton pregnancies, the risk of a twin baby dying in the first month after birth is between four (57) to eight times higher (128). A large cohort study (N= 17,751 live births) in Ghana observed that multiple birth was significantly associated with an increased risk of neonatal mortality (57). Bivariate analysis had indicated that multiple births (OR: 3.46; 95% CI: 2.50- 4.80) could be associated with neonatal deaths and interestingly the estimates increased slightly (OR: 3.91; 95% CI: 2.79- 5.49) after adjusting for potential confounders. Another study noted that multiple births (adjusted OR: 5.22; 95% CI: 3.61- 7.54) was a significant risk factors for early neonatal deaths. Although the authors adjusted for gestational age, it was calculated from maternal recall of last menstrual period which could be inaccurate and consequently lead to undifferential misclassification bias and consequently underestimate the odds ratios (145). Multiple births have also been associated with preterm birth and low birth weight, which are both significant risk factors for neonatal mortality (146, 147). The risk of death among twins was especially higher for the second twin compared to the first (148-150) and twins who were delivered via planned caesarean section had a significantly lower risk of death compared to those delivered via other means (149).

There is little evidence in support of the hypothesis that longer birth intervals maybe associated with lower risk for mortality. A recent mata-analysis of cohort studies found significant association between birth interval and SGA, preterm birth and infant mortality but not for neonatal mortality (46). Secondary analyses of DHS in Ghana also found that compared to women who had at least 36 months of birth spacing, the risk of neonatal mortality was high among women with 18-36 months birth spacing (OR: 1.22; 95 % CI: 0.77- 1.93) and higher among those with less than 18 months birth spacing (OR: 3.49; 95% CI: 1.60- 7.59) (27). Similar findings were reported in another secondary analysis of DHS from six other West African countries, including Ghana (128).

2.12 Cultural and birth practices associated with neonatal mortality

The WHO has developed a set of evidence-based practices to help maternity care providers care for mothers and newborns during pregnancy, delivery and postpartum (151, 152). These guidelines, titled Pregnancy, Childbirth, Postpartum and Newborn Care: A Guide for Essential Practice (the PCPNC Guide), also come with a training manual and workbook to help maternity care providers acquire the essential knowledge and appropriate skills. The newborn care sections include standards for clean delivery and cord care, thermal protection including wrapping and skin to skin care, breastfeeding practices including early initiation and exclusive breastfeeding, resuscitation, eye care, immunisation, care of a low birth weight baby and management of neonatal illnesses. These recommendations are considered ideal to ensure highest survival for newborn babies. To ensure their acceptability, these recommendations must be in accordance with local birth practices and beliefs, and across all maternity settings. It is therefore important to understand existing birth practices between maternity practices in order to design appropriate behavioural or educational interventions to change harmful practices.

This review identified about a dozen studies who have written on birth practices in sub-Saharan Africa which may influence newborn health. The majority of these studies were interviews or focus group discussions involving women who had recently delivered (79, 80), others used multiple approaches including expert interviews, participant observations, narrative histories and questionnaire surveys (99, 153, 154), a few were surveys (82, 155) and one study involved a rare sample of women who accompanied labouring mothers to maternity units (78). Major newborn care practices reported in these studies include breastfeeding practices, bathing and wrapping babies, use of herbal medicines and umbilical cord care. Overall the studies showed low uptake of appropriate newborn care practices in sub-Saharan Africa. There was late initiation and mixed breastfeeding practices, poor thermal care, application of various substances to the umbilical cord and treatment of newborn diseases using herbal medications without evidence of efficacy.

Breastfeeding is arguably the most widely promoted birth practice in Africa. This review found that almost all women in Africa breastfeed but less than 60% of women were reported to adhere to appropriate breastfeeding recommendations (82, 156) and there were important cultural practices which influenced breastfeeding habits in the neonatal period. There was variation in the time for initiating breastfeeding and breastfeeding habits according to where babies were born. The WHO and the National Institute for Health and Care Excellence (NICE) recommend that breastfeeding be initiated within the first hour of birth (152, 157), and a study from Ghana has attempted to draw a causal inference between delayed breastfeeding and mortality (158). In the Pemba district, Tanzania, it was reported that only 40% of mothers initiated breastfeeding within an hour of birth, and a majority of mothers did complementary feeding in the first week (79). Another study in the rural Lindi and Tandahimba districts of Tanzania noted that babies born in hospitals initiated breastfeeding soon after delivery (80). A study among adolescent mothers in Uganda has also shown that knowledge about appropriate birth practices predicted optimal appropriate newborn care practices (156). It is plausible that mothers who delivered in health facilities had more knowledge about appropriate newborn care. In Ethiopia (155) and in Uganda (82), however, the difference in breastfeeding practices by place of delivery was not statistically significant. The Ethiopian study included only 218 mothers and the Ugandan study had 393. Therefore these studies may have been underpowered to observe any statistically significant differences. Other breastfeeding habits reported included prelacteal feeding behaviours, mixed feeding, bottle feeding and denying babies colostrum because it was perceived as dirty (79, 80, 82, 155). Complementary foods reported in the first month of birth included porridge, tea and biscuit, thin gruels, sweetened water and milk because mothers believed that the breastmilk was insufficient to satisfy babies as evidenced by the baby licking his or her fingers after breastfeeding or crying. These practices are contrary to recommendations (152, 157).

The most popular thermal practice reported was wrapping newborn babies with cloth following delivery. The majority of studies reported that mothers knew that babies needed to be wrapped to provide extra insulation against heat loss (79, 159). In Tanzania it was reported that babies were wrapped with new and clean bright clothes, known as *khangas*, as it was believed old ones brought bad luck (79). Some studies in Ghana and Tanzania have reported a delay in wrapping babies among at least 70% of babies delivered at home, as babies were left unattended until the placenta was delivered and the cord cut. Delay in drying or wrapping babies, or early bathing could lead to evaporation and excess heat loss. Another reason given for drying babies, especially among home births, was to clear the vernix because it was believed that it could lead to body odour or eye problems later in life (78, 79). Some mothers and care providers at home even bathed newborn babies with cold water soon after delivery to clear the vernix (82, 106, 159). Significant differences in time for initiation of bathing between babies born at home and those born in health facilities have been reported in Ethiopia, with delayed bathing noted in the latter group (155). Skin to skin care was under practised, or underreported in most of the studies. Yet it was more common for babies to be delivered onto the abdomen of the mother or to attach the baby to the mother’s skin immediately following delivery in health facilities, and almost non-existent among those who delivered at home (79, 82, 155). Skin-to-skin care helps early bonding between mother and child and also helps with heat regulation for the baby.

Hypothermia contributes a great deal to neonatal mortality in Africa (160, 161). This is because newborns have difficulty regulating their body temperature and they lose heat easily due to their large surface area (162). Preterm babies are therefore at highest risk. It is advised that newborns are wiped with a dry cloth and covered immediately following delivery to reduce evaporation and hypothermia. Despite a consensus that wrapping babies, skin to skin care and delayed bathing may help to reduce hypothermia in babies; however, there is very little evidence from randomised controlled trials to substantiate the individual contributions of these interventions (163, 164). In Ghana, it has been reported that mothers were not receptive to changing bathing habits but considered trying skin-to-skin care if it would help babies (159).

Umbilical cord practices reported in this review were suboptimal, with significant differences observed between babies delivered in health facilities and at home. The majority of maternity care providers were reported to cut the umbilical cord using sterile equipment in hospitals and at home, but some used old razor blades and others used other substances like sugarcane straw or millet stem (80, 82). Most care providers used a thread or cord to tie the umbilical cord, but some used strings from ensete plant (false banana) (155). While midwives in hospital or clinic kept the umbilical cord stump dry and a few used chlorohexidine, care providers at home used various substances including butter, charcoal, ash, salt water, lizard droppings, breastmilk and other substrates to dress the umbilical cord stump (56, 78-82). These substances were applied in order for the cord stump to fall early because it was believed that until the stump fell, it was easy means for evil spirits to attack the baby, and so a person with ‘good hand’ was made to cut the cord stump (80, 82). The WHO recommends that the newborn stump be kept dry, as introducing substrates to it may cause infections.

The use of herbal medications in treating newborn illnesses is very common in Africa. It was reported to be the first line of treatment (154), and a general poor health seeking behaviour for newborn illness has been noted (153-155). The use of herbal medications is rooted in beliefs that some diseases are of traditional origins and “do not respond to hospital medicine” (79) or “are not meant for the hospital” (153, 154). They are believed to be caused by spirits, or transferred from a person with ill will for the baby- either in utero or after birth when the cord stump has not fallen off yet after delivery (19). This has implications for who should be present or who is allowed to see the baby in the immediate postpartum period. The most common ‘traditional disease’ in Ghana is *asram* (153, 154). A complex taxonomy for asram has been published and it includes a wide ranging list of danger symptoms (153), but classical signs are conspicuous green or dark veins, a big head, difficulty breastfeeding and the baby begins growing lean. Similar beliefs about traditional diseases have also been described elsewhere in Eastern and Southern Africa (78, 79).

Mothers were unlikely to send babies believed to suffer from traditional diseases to the health facility. Treatments for these traditional diseases include burning herbs and directing the medicinal smoke towards the sick baby, herbal bath, or oral herbal medications. The herbal mixture for bathing babies was usually cold, as warm mixture are believed to reduce the potency of the drug, and allowed to air-dry on the babies skin. It is believed that if appropriate measures are taken by mothers during pregnancy- herbal bath, taking oral herbal medications, avoiding eating in public places- these traditional diseases could be prevented. Assuming the herbal medications are effective in treating asram, such practices, unfortunately, increase risk of newborns to hypothermia. There is also little evidence supporting the effectiveness of these herbal medications and previous studies have found some herbs to be harmful or poisonous (165-167). Understanding traditional causes of neonatal illness has implications for policies designed to improve health seeking behaviour for neonatal diseases. For other neonatal diseases which were not attributed to spiritual origins, such as stomach ache and diarrhoea, mothers were reported to buy drugs over the counter and rarely sought skilled care (79, 154).

Other traditional practices have been reported among various cultures in Africa. These include applying kohl or soot to disguise the face of the baby, applying garlic on the baby to scare away evil forces (79), ritual burying of the placenta to maintain the fertility of the mother (78, 79), moulding the head of the baby with hot water to give it a nice shape or massaging the newborn with coconut oil to strengthen his bones (79). Most of these practices are rooted in sociocultural beliefs and understanding of the causes of newborn illnesses and death, and may lack scientific explanations to support them. The potential consequences of most of these 'other practices' are not clear and further studies may help to clarify.

This review summarises the growing body of evidence on beliefs and birth practices associated with neonatal mortality in Africa. Most of the studies in this review used interview approaches which are also subject to recall bias. It is also possible for interviewees to censor information given to interviewers. Most of these studies also used populations of recently delivered women or community informants, and not maternity care providers who play a key role in delivery. Interviewing maternity care providers offers the added advantage of providing information on both intra- and post- partum birth practices since TBAs or midwives are knowledgeable about local birth practices and also care for mothers and their babies in the immediate postnatal period. Many women also receive newborn care advice from their care providers during antenatal and delivery. Although there were many similarities, this review shows some variations in birth practices, or beliefs underlying similar practices. This means that results from one country or culture cannot be generalised to other contexts. Newborn care interventions ought to be context specific and designed to address beliefs underlying specific practices.

2.13 Conclusion

NMR is an important measure of the quality of maternal and newborn care in a country, and therefore a reliable estimate has important programmatic implications. The lack of reliable vital registers in developing countries, however, means that NMRs are estimated from complex statistical modelling which may be unreliable. The association between place of delivery and neonatal mortality is also not clear, and most of the studies do not differentiate between the different forms of health care facilities. In these countries, surveillance systems which cover smaller communities may provide much more reliable estimates. There is also a growing interest in the qualitative research paradigm about the influence of cultural patterns and birth practices on newborn health. The majority of these studies however, focused on the perspective of mothers only which is one-sided, and those which included maternity care providers interviewed TBAs only. There is therefore a need to understand, from the perspective of maternity care providers including doctors, midwives and TBAs, how cultural practices, family structures and decision-making influence neonatal mortality and to also compare the birth practices between the different cadres of maternity care providers and their potential impact on neonatal mortality.

Chapter 3 Methodology

3.1 Introduction

This thesis uses a multilevel mixed-methods design to investigate neonatal mortality in Ghana and Scotland, including rates, trends, risk factors and contextual factors. The first level of the design used quantitative methods to estimate the neonatal mortality rates (NMRs), trends and risk factors using information on delivery records (from babies and their mothers) in Ghana and Scotland. The second level used a sequential explanatory mixed methods design (i.e a quantitative method followed by qualitative method) to investigate the practices of maternity care providers which may contribute to neonatal mortality. The overall study design, therefore, was made of three strands or phases.

1. 2°QUAN: Quantitative analyses of routine data from Ghana and Scotland to determine the rates and risk factors for neonatal mortality.
2. 1°QUAN: Questionnaire survey of the maternity care providers in Ghana
3. qual: In-depth interviews of maternity care providers (from 1°QUAN phase) who said they had experience of the adverse neonatal outcomes- birth asphyxia, prematurity, infection and mortality. (The 'qual' strand is in lower case because it complemented 1°QUAN phase according to the Morse (2003) notation for mixed methods research (168))

Fig 3.1 depicts the various stages in this multilevel mixed methods design. This chapter discusses the methodology for the overall thesis, the philosophical basis, study settings and the ethical considerations. Details of the individual methods for data collection and analyses for each strand of this thesis are described separately in the respective data chapters (4-7).

3.2 Study objectives

The objectives of the thesis were;

1. To determine and compare the NMRs in three regions of Ghana
2. To determine whether the NMRs in these regions have changed over time
3. To determine the distribution of neonatal deaths by age at death and underlying cause of death in Ghana
4. To determine factors associated with neonatal mortality in Ghana

5. To explore birth and cultural practices associated with neonatal mortality in Ghana.
6. To compare Ghana and Scotland in terms of overall, early and late neonatal mortality and the factors associated with neonatal mortality.

3.3 Philosophical assumptions: Mixed methods or mixed-up methods?

The challenges facing public health today are globalised and the determinants of health are interrelated. Public health research has thus become increasingly complex and epidemiologists are asking more difficult questions for which the traditional methodological dichotomy- of qualitative or quantitative approaches- is not sufficient to answer. This is more so in low and middle-income countries where the factors influencing health are more complex and yet poor data collection systems limit epidemiological studies. Mixed methods studies, also known as the third methodological paradigm (168), therefore, provide a unique opportunity to combine both qualitative and quantitative methods to understand the issues confronting public health, especially in developing countries. Yet there are some schools of thought that still question the value of mixed methods studies, arguing that it is unreasonable to combine two otherwise opposing methodological approaches in a single study.

Several definitions of mixed methods abound, based on different elements of the research process, methods, philosophy and research design (168, 169). Earlier researchers who focused on combining methods defined mixed methods as a study design which incorporates at least one quantitative and one qualitative method, and none of the two methods are inherently linked to any other research paradigm (170). A decade later, the definition evolved to include a methodological orientation: mixing in all phases of the research process (168). A more recent, and more comprehensive, definition for mixed methods has been suggested by Johnson, Onwuegbuzie and Turner (171). After seeking consensus on a definition which incorporated elements of what was being mixed, the stage at which mixing took place, scope of mixing, purpose of mixing and purpose of the research, the authors defined mixed methods design as “a type of research in which a researcher combines elements of quantitative and qualitative research approaches (viewpoint, data collection, analysis and inference techniques) for the purpose of breadth and depth of understanding and corroboration". This thesis adopts the latter definition to investigate the rates, trends, causes of death and risk factors for neonatal mortality in Ghana.

The use of mixed methods design is not new (172, 173) but development of the underlying philosophies and procedures did not occur until the late 1980s when many authors across several disciplines attempted to describe and define it (170, 174, 175). In the historical Hawthorne studies entitled *Management and the Worker* by Mayo and Roethlisberger (1949), for example, the authors conducted a series of quantitative experiments (Phase I) and qualitative interviews (Phase II) to explain how relations in the work place could be improved and why production continued to increase despite experimental changes in working conditions (173). Today the popularity of mixed methods design is widespread in medicine and nursing, education, psychology and in social sciences. The number of journals, conferences and books on mixed method designs is also increasing.

There is lingering debate about the use of mixed methods as an accepted method for scientific inquiry. The arguments range from minor issues concerning the operational definition to grave concerns about its value. The oldest, and perhaps most famous, debate surrounds the integration of the two methodological designs with allegedly different paradigmatic assumptions. This argument, however, is an important one because the underlying philosophy shapes the research processes and how information is gathered and knowledge is generated. Quantitative methods are associated with the positivist world view and qualitative methods are associated with the constructivist world view (176). To the 'purists', according to Rossman and Wilson (177), it is 'untenable' to mix these two world views (178) but to the 'pragmatists', it is possible to integrate multiple paradigms to address research problems (177). It is argued that a single world view tends to focus more on individuals and their experiences or other society-level norms. Reality in a complex healthcare environment is, however, multi-faceted and human behaviour is not harmonious. A more flexible methodology, which meets the method-specific criteria for rigour can, therefore, support a world-view that incorporates this complex reality.

Another nuance in the mixed methods world view, the dialectical perspective (179), encourages the use of multiple paradigms in a single study, rather than integrating two paradigms into one (180). The dialectical world view recognises that the use of different world views in a single study could lead to contradicting ideas, but the authors argue that this demonstrates different ways of discovering the social world which needs to be 'acknowledged and not reconciled'. The last world view, termed the "paradigm shift" world view, like the dialectical perspective encourages the use of multiple paradigms in a mixed methods study but differs from the latter in the sense that its use is dependent on the type of mixed methods study rather than how the researcher seeks to discover the world (180). Proponents of the "paradigm shift" world view are open to the possibility of a change in paradigm as the study moves from the quantitative phase to a qualitative phase, thus a shift from positivist to constructivist (in an explanatory design), and vice versa (in an exploratory design) or pragmatism in a convergent mixed methods design (180). Further information on the "Eleven key controversies and questions being raised in mixed methods research" has been published elsewhere (181).

I refrain from prolonging the esoteric 'paradigm war' by stating that I adopt the paradigm shift world view because of its practicability to the current research questions and methodology (168). Although there are some who suggest that the pragmatist world view is the 'one best' for mixed methods study (168), I concur with others like Cresswell and Plano (179) who argue that many world views could be used in a single study based on the type of mixed methods study. This thesis first analyses secondary quantitative data and follows up with a questionnaire survey and then in-depth interviews of maternity care providers. There is, thus, a clear shift from the positivist paradigm to a constructivist paradigm. The use of multiple world views in a single mixed method study also allows me to employ the ontological and methodological stances of both quantitative and qualitative methodologies (179). During the quantitative strand of the thesis, I employ a singular ontological stand as I analyse a set of variables to determine the risk factors associated with neonatal mortality. This is a top-to-bottom approach which 'confirms' or 'rejects' an a priori hypothesis or theory. Moving to the qualitative strand, I employ a multiple ontological stance as I try to explain the risk factors identified in the quantitative phase through the eyes of health care providers. This is a more bottom-up approach that seeks to produce a theory which explains the quantitative risk factors.

The decision to adopt the paradigm shift world view as the philosophical foundation for the current mixed methods design was, however, not without some contemplation. I pondered pragmatism because of its problem-centeredness and its focus on the consequence of the research rather than the methods (179). Yet I believe that the influence of the research methodology on the level of evidence generated and thus the consequence of the research cannot be overlooked (145). The conflict between pragmatism and paradigm shift world views was clarified by Creswell and Clarke (2007) who propose, “if, instead of implementing the different approaches [methodologies] in phases, a mixed methods researcher collects both quantitative and qualitative data in the same phase and merges the two databases, then an all-encompassing world view- [pragmatism]- might be the best for the study” (p. 46) (179). This thesis collected and analysed quantitative data separately using appropriate statistical methods, and then qualitative data separately using suitable qualitative techniques and the two databases were not merged. This is supported by Cresswell (182) who states that the paradigm shift philosophy best suits the explanatory design (182).

The interest of researchers in using mixed methods keeps growing because of its intuitive and pragmatic nature. Cresswell and Clark (179) see mixed methods as a ‘natural outlet’ for conducting research because it provides multiple perspectives on a phenomenon, and multiple dimensions are a part of life in the complexity of the real world. In the field of education, researchers have used sequential explanatory mixed methods design to understand the impact of note-taking conditions on student learning from a web-based text (183-185). In a study published in the *Journal of Mixed Methods Research*, Igo, Kiewra and Bruning (183) collected experimental data (quantitative) testing the influence of how different levels of copy-and-paste restrictions on web-based text influenced learning. The results from this experiment contradicted what was common knowledge at the time. Subsequently, the authors followed up with interviews of small samples of participants in the experiment to help explain their scores for experimental outcomes. Similarly, in the public health literature, mixed methods have been used to investigate the role that older-aged parents play in the care and support of adult children with HIV/AIDS and AIDS orphans (186). The authors in this study collected quantitative survey data and open-ended interview data from parents, referred to as AIDS parents, who had lost a child to AIDS. The AIDS parents' survey consisted of 394 structured interviews with parents who recently lost one child, or more, to AIDS. Then, an open-ended interview was conducted with 18 AIDS parents who provided care to a terminally ill child. Reflecting on the interview process, the authors indicated that although the issues covered were similar to the AIDS parents' survey, "the conversational nature of the interview and the fact that it allowed open-ended responses provided parents the opportunity to elaborate on issues and circumstances affecting them", thus providing further insight (186). Other examples of studies that have employed the explanatory design show that they can be applied to a wide range of research questions (184, 187-189).

This thesis employed a mixed method design for two main reasons. Firstly, one data source was not sufficient. Secondly, quantitative results needed to be explained. Quantitative studies are known to provide a more general understanding of a problem, while qualitative studies can provide more detailed explanations (176). This thesis is exploring contexts and mechanisms in which deaths occur (hence requiring qualitative methods) and also identifying and comparing rates and distributions of neonatal mortality (which calls on quantitative data). Previous studies in Ghana have used the large quantitative datasets from Navrongo and Kintampo to investigate the risk factors and causes of neonatal mortality (14, 28, 57, 59), but they did not consider the effects of place of delivery. There is also no study on neonatal mortality from the Dodowa surveillance system, neither has there been an effort to pool these datasets from the three surveillance systems together. Doing so increases the sample size, and provides sufficient numbers to analyse the differences by type of health care provider, compare NMR by region and possibly allows generalisation of the results nationwide. While previous quantitative studies showed that infections, asphyxia and prematurity were the leading causes of death and also identified some maternal and neonatal factors related to neonatal deaths, they failed to explain how health care delivery, including birth practices, and cultural factors contributed to the identified causes of death. The surveillance dataset, unfortunately, does not contain data on maternity service delivery and practice. A questionnaire survey of maternity care providers, therefore, sought to identify aspects of practice that could be related to neonatal mortality. Finally, in depth interviews with maternity care providers (i.e. doctors, midwives and traditional birth attendants) who had experienced adverse neonatal outcomes including neonatal death provided deeper understanding of how birth practices, health care delivery setting and cultural beliefs contributed to neonatal deaths.

The complementary use of qualitative and quantitative approaches to investigate neonatal mortality therefore provided a more complete picture of neonatal mortality in Ghana. In addition, the strengths of the quantitative study (i.e. representativeness and generalisability) offset the weakness of the qualitative study, and the strengths of qualitative study (i.e. in-depth understanding) offset the weakness of quantitative studies. By interacting with health care personnel, I also gained a clearer understanding of the context and setting in which health care providers practise and was also able to put faces behind the statistics and thus maintain the human element of epidemiology- a thing which is often overlooked.

Before ending this section, it is important to state that the use of mixed methods designs presents significant challenges. They require the researcher(s) to have the time, resources and skillset to handle both qualitative and quantitative data. The cost and time needed to collect and analyse quantitative and qualitative data may be prohibitive. The most important challenge with mixed methods, according to Creswell and Clark (179), is “educating and convincing others of the need to employ a mixed methods design so that a researcher’s mixed methods study will be accepted by the scholarly community” (p. 13). This is why I have dedicated a whole section to justify the use of a mixed methods design to investigate neonatal mortality in Ghana.

3.4 Study design: multilevel mixed methods study

A multilevel mixed methods design refers to the application of quantitative and qualitative methods to different levels of a system. It has been described extensively by many authors (168, 190-192) and according to Cresswell, Plano Clark, Gutmann and Hanson (2003), in the *Sage Handbook of Mixed Methods in*

Social and Behavioural Research (168), it is the 'most popular' typology of the mixed methods designs. Many researchers have also used multilevel mixed methods designs to investigate various phenomena (191, 193, 194). Elliot and Williams (193), for example, used a multilevel mixed methods approach to evaluate a counselling service among a fire brigade by collecting data on several stakeholders at different levels: clients, counsellor, and organisation. The choice of the current methodology in this thesis was informed by the research questions, which aimed to investigate neonatal mortality at the babies' and mothers' level and at the level of the maternity care provider.

To determine the NMR and trends and risk factors, existing data on newborns and their mothers from the Navrongo, Kintampo and Dodowa health and demographic surveillance systems (HDSS) in Ghana were analysed (2°QUAN). Similar quantitative data were extracted from the Scottish maternity and neonatal linked database (i.e. Scottish morbidity record (SMR 02) and national death records (NRS). Since these secondary data from the HDSS in Ghana did not contain information on birth practices, the 2°QUAN phase was followed with a questionnaire survey (1°QUAN strand) of maternity care providers within the surveillance areas to assess the neonatal birth practices and health care related factors which influenced neonatal mortality. Finally, maternity care providers included in the questionnaire survey served as a sampling frame for in-depth interviews with those who experienced any of the adverse neonatal outcomes of interest. This helped to generate free text statements about birth practices that may provide insights into the causes of neonatal mortality. In Scotland, birth practices, maternity care protocols, and management protocols for newly born babies are readily available in published guidelines (https://www.nice.org.uk; http://www.sign.ac.uk).

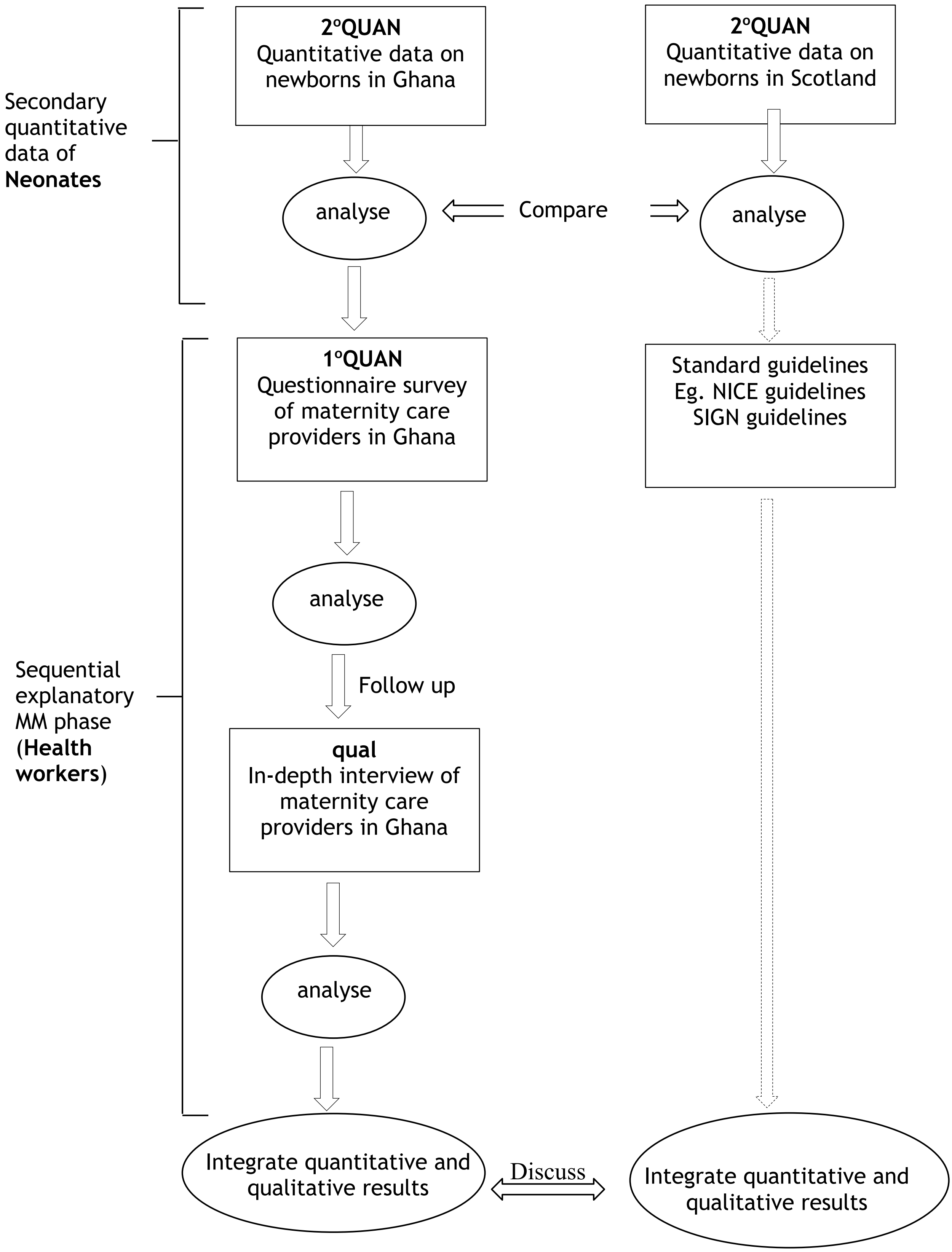


Fig 3.1: Model for a multilevel mixed method study of neonatal mortality
(A quantitative study followed by an explanatory sequential mixed methods design**)**

3.5 Study setting

This study was conducted in Ghana and Scotland. In Ghana, the study was conducted in three regions where there are established health and demographic surveillance systems (HDSS). Based in Navrongo, Kintampo and Dodowa, these ongoing surveillance systems collect primary community-based data on births, deaths, pregnancies, marriages, migration and vaccination coverage from northern, central and southern parts of the country respectively. Details about of the methods used in these HDSS are described later in chapter 4.

The Navrongo Health Research Centre (NHRC), located in the east Kassena-Nankana district of the Upper East Region, near the border with Burkina Faso, manages the Navrongo Health and Demographic Surveillance System (NHDSS) which covers the east and west Kassena-Nankana districts of Ghana. It is responsible for monitoring health and demographic dynamics and facilitates evaluation of the morbidity and mortality impact of health and social interventions in northern Ghana. Established in 1992, the NHDSS has data on over 32,000 households and 150,000 residents in an area of about 1,675km^2. The area has largely savannah vegetation with short periods of rainfall and a prolonged dry season. About 80% of the area is rural with the local economy mainly comprising subsistence farming and tourist attraction sites. The surveillance area comprises two major ethic groups; the Kassems in the east and the Nankans in the west. There is a mixture of traditional dwellings made of mud and thatch roofing and more modern structures using cement blocks and aluminium roofing sheets. The surveillance area is operationally divided into north, south, east, west and central zones, which are further subdivided into 247 clusters. Each cluster has an average of 70 compounds and a maximum of 99. The area has one referral district hospital, seven health centres and 27 community health compounds (19). The road network in Navrongo is largely feeder with asphalted roads between major towns. The main means of transport is motor bike. The fertility rate of the area had declined from 5.1 children born per woman in 1995 to 3.8 in 2011, with life expectancy increasing from 43 to over 60 years over the same period (19). In 2011, there were nearly 4,000 live births. A previous study in the Kassena-Nankana district determined the NMR

(2003-2009) as 24 (95% CI; 22- 26) (57). The NHDSS is described in detail elsewhere (19).

The Kintampo Health Research Centre (KHRC) manages the Kintampo Health and Demographic Surveillance System (KHDSS). It covers an area of 7,162 km^2 in the north and south Kintampo districts in the Brong Ahafo region of central Ghana. The area lies on the forest-savannah transitional ecological belt. About a third of the KHDSS is urban and the remainder rural. The major tribe in the Kintampo HDSS is Akan. Established in 1994, the KHDSS contains about 30,000 households with over 150,000 individuals. In 2009, there were nearly 4,317 births in the district, approximately 45% of which took place at home. There are two district hospitals in the Kintampo HDSS. Approximately 50% of births and 40% of neonatal deaths occur in the main district hospital (195). The NMR in the Kintampo district in 2004 was estimated to be 30.6 (59).

The Dodowa Health Research Centre (DHRC) manages the Dodowa Health and Demographic Surveillance System (DHDSS) in the south-east of Ghana, near the capital Accra. Established in 2003, the DHDSS contains over 22,500 households with 100,000 residents. The DHDSS covers an approximate area of 1,530 km^2 between the boundaries of the Shai-Osudoku and Ningo-Prampram districts in the Greater Accra region. The area is largely coastal savannah, with about a quarter of the area being a dense forest zone. It is largely a rural community with farming, fishing and petty trading as the most common occupations. The people within the DHRC are predominantly Dangbes and the majority are Christians. Health care in the area is provided by 21 health facilities, including two hospitals and 19 community health compounds, 150 public health outreach sites, 5 pharmacies, 5 laboratories (3 public and 2 private) (20). There is a well-laid asphalt and feeder road network in Dodowa and the major means of transportation within the Dodowa surveillance area is by car, but the roads could be inaccessible during the wet season. As at 2010, 15.2% of the total population was aged less than 5 years. In the primary paper describing the profile of the HDSS, the following statistics were given for the Dodowa surveillance area (2010); crude birth rate: 23.5 per 1,000 per year; total fertility rate: 2.7; NMR: 8.8 (20). The HDSS is described in more detail elsewhere (20).

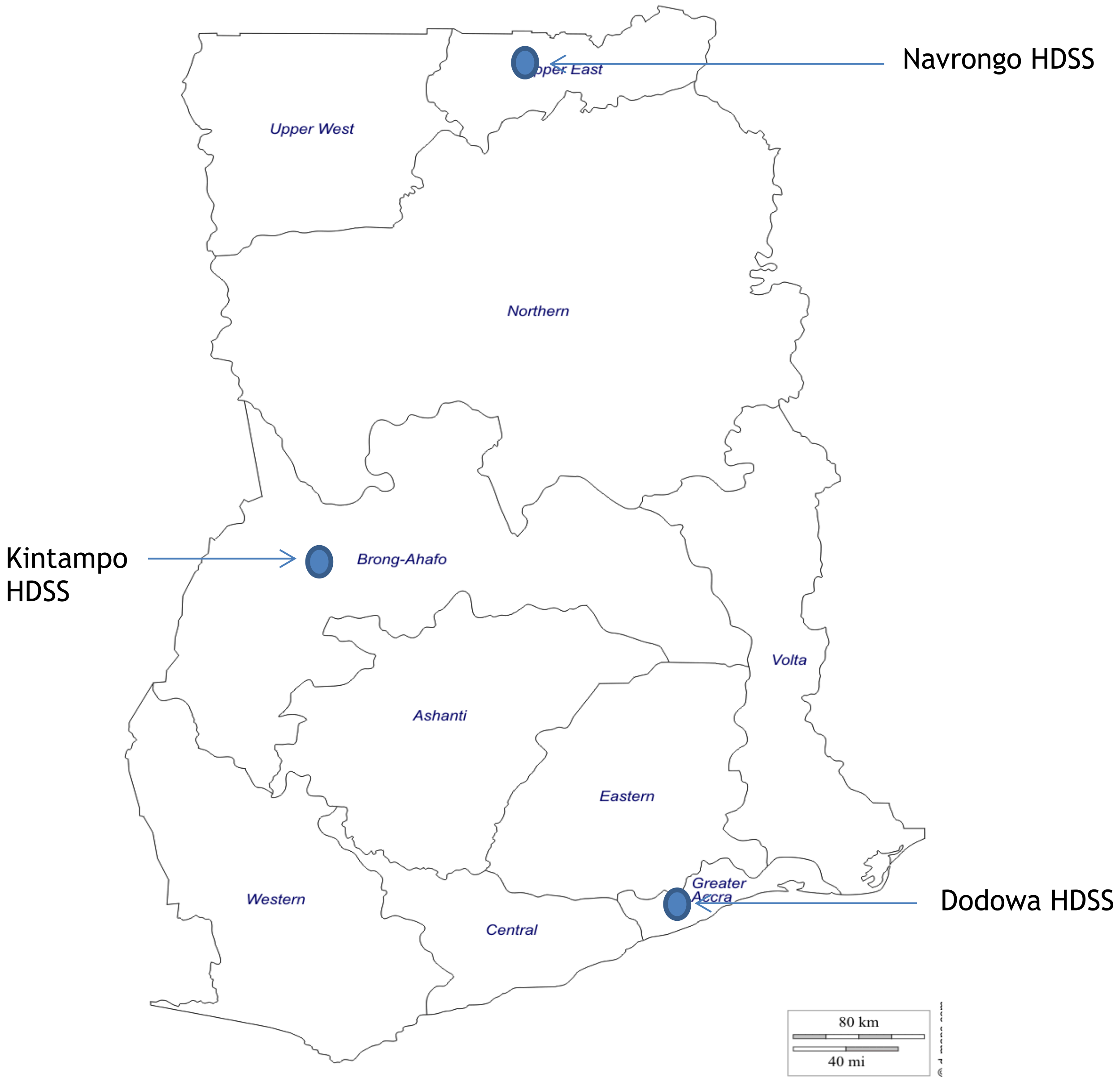


Fig 3.2 Outline of the map of Ghana showing the HDSS sites

Source: http://d-maps.com/carte.php?num_car=26841&lang=en

Scotland is one of the countries in the United Kingdom of Great Britain and Northern Ireland, and it covers the northern third of Great Britain. With a land mass of 78,387 km^2, it contains a population of approximately 5.2 million people. It has a varied geography from rural lowlands to barren uplands and from large cities to islands. The birth rate in Scotland is 11.3 per 1,000 population and the NMR was reported to be 2.6 per 1000 live births in 2012 (196, 197). The whole population has access to primary and secondary care provided by the National Health Service (NHS) which is largely free at the point of delivery. In Scotland, the vast majority (about 98%) of deliveries occur in National Health Service hospitals and are provided free of charge.

In Ghana, maternity care is provided by both ‘professional’ birth attendants and ‘non-professional’ attendants. Professional attendants include doctors, midwives, nurses, community health nurses and midwives and auxiliary midwives. Non-professional birth attendants are traditional birth attendants (TBA) who may have been trained by the Ghana Health Service (GHS) or from other informal settings such as their parents. The main settings for maternity care provision in the three health and demographic surveillance areas in Ghana are hospitals, clinics and homes. Care is provided by doctors and midwives in the hospital, midwives and nurses in clinics and TBAs in homes. Since around 2013, TBAs in Navrongo have been discouraged from conducting home deliveries and in some communities, it is an offence punishable by a fine for a TBA to conduct unsupervised delivery. These TBAs were encouraged to accompany women in labour to the nearest clinic or hospital by being offered monetary payments or gifts. There is no published document assessing the coverage, duration or effectiveness of this policy but anecdotal evidence suggests it has been operational for at least three years.

Health care financing in Ghana includes the state owned National Health Insurance Scheme (NHIS), private health insurance schemes, and personal expenditure. Adopted in 2003, the NHIS is the biggest health insurance scheme in the country with approximately 62% of Ghanaian women registered (10, 198). It covers both prenatal and delivery care services, including normal and assisted delivery and management of complications arising out of deliveries, in public, private and faith-based health facilities (199). The general public is expected to pay an annual premium of at least GHC 30.00 (£5.19) to register with the scheme but pregnant women are registered for free after pregnancy is confirmed by a doctor. Although legally mandatory, in practice membership is voluntary and there are no sanctions for not enrolling (200). Although the NHIS is supposed to cover major maternity costs, there are still some essential newborn services which are not covered and there may be other reasons why mothers have to spend out-of-pocket. The 2014 demographic health survey noted that about 37% of women who said they were registered with the NHIS still had to self-fund some medicines or services at the health facility (10). It was revealed during the field study that some investigations ordered by physicians including ultrasound scans were not covered under the NHIS. Moreover, items for delivery or newborn care were often out of stock thereby causing families to buy them and some essential drugs for the newborn were not included in the National Essential Drug list. Mothers could therefore spend between GHC 100 to GHC 300 out-of-pocket for an uncomplicated vaginal delivery and the cost for a caesarean section could be at least GHC 200. In addition, the second postnatal care visit is not covered by the NHIS and payment of ‘unofficial fees’ was common. Other financial challenges facing the health system include: limited funding, inadequate and irregular financial resource flow and delayed reimbursement of NHIS (38, 200-202).

3.6 Data sources and sampling

This thesis used a multilevel mixed method sampling as the overall sampling technique to select neonates and maternity care providers included in the study. It is important to distinguish multilevel mixed method sampling, as a method, from multilevel mixed methods design as a methodology. Multilevel mixed methods sampling often involves the application of both probability and non-probability sampling methods to select participants at different levels of a mixed method study (168, 203). Onwuegbuzie and Collins (204) offer a more liberal definition as the combination of any two sampling techniques, which could be at least two random sampling techniques or two purposive sampling techniques, at different levels in a mixed method study.

The 2^{o}QUAN strand (routine data from Ghana and Scotland) used population data of neonates and their mothers in Ghana and Scotland, and the methods involved in data collection have been described earlier (19, 20). In Ghana, trained field officers visit every home within the HDSS two to three times each year to collect key epidemiologic events of interest. Birth and death data are collected using the birth registration form and verbal post mortem (VPM) forms respectively, and events recorded by the field workers are double checked by a field supervisor for validity before they are sent to the research centres and subsequently entered by data managers. In Scotland, routine data on pregnancies, births, morbidity and deaths are recorded in the Scottish Morbidity

Record and data on deaths are available in the National Record of Scotland's infant death register. Details of the methods used in Ghana by the HDSSs are discussed in Chapter 4 and in Scotland, in Chapter 5.

The 1ºQUAN strand of the design used stratified purposive sampling to recruit maternity care providers for a researcher-developed questionnaire survey (Chapter 6) and the qual strand used purposive sampling to recruit a smaller sample of maternity care providers involved in the questionnaire survey for a semi-structured in-depth interview (Chapter 7).

Although this study is not the first to use a multilevel mixed method sampling to select study participants, it is one of the few to my knowledge to apply multilevel mixed methods to investigate neonatal mortality. Multilevel mixed methods sampling is common in studies concerned with investigating different levels of a phenomenon or organisation, and each level is a separate unit of analyses. In pre-university school settings (primary school to high school), multilevel mixed methods sampling has been used to study teachers and pupils or school districts and schools (194). Each level of analysis may require a different sampling technique. The current study sought to investigate neonatal mortality from the neonatal, maternal and health care provider levels.

The chosen sampling technique for the multilevel mixed methods design was informed by the complexity of the research questions and the dynamics of the population under study. The primary aim of the sampling strategy was to attain both representativeness and maximum variation- to include all cadres of maternity care providers and all types of delivery settings in Ghana. This is in accordance with the recommendations for sampling in qualitative research, particularly where there is little previous research on the topic under investigation (205, 206). The double aim of representativeness and maximum variation would be achieved by combining probability and non-probability sampling techniques respectively (203) (207) (208). The use of both probabilistic and non-probabilistic approaches also allowed me to increase the external validity and transferability of the study, which would otherwise be impossible with only one sampling approach. Probability sampling techniques are traditionally known to select a large number of cases that are representative of the population under study (concerned with breadth) and purposive samples select smaller numbers that are most informative about the issue under investigation (concerned with depth). Mixing both approaches therefore allowed me to carefully sample a reasonable size which had both ‘depth and breadth’ in relation to the phenomenon under investigation. The Purposive-Mixed-Probability, or Probability-Mixed-Purposive, sampling continuum and their trade-offs have been described in depth elsewhere (208).

3.7 Data management

This study used quantitative and qualitative data from multiple sources in order to answer the research questions. Table 3.6.1 summarises the different sources of data, type of data and population used at each stage of the multilevel mixed methods study design.

The table shows that the populations for the 2ºQUAN strand of the multilevel mixed methods were neonates and mothers in 1) the three HDSS areas in Ghana and 2) the whole of Scotland. The data were provided by the three health research centres in Ghana and the Information Services Division in Scotland respectively. The population for the 1ºQUAN strand was maternity care providers in the three HDSS areas in Ghana (doctors, midwives and traditional birth attendants) and data were collected using a researcher-developed questionnaire. Maternity care providers recruited in the 1ºQUAN phase served as sampling frame for the qualitative strand (qual) of the multilevel mixed methods design. A catalogue of the variables used, operational definitions and the number of observations, instruments used for data collection, data quality and management are discussed in the methods sections in Chapters 4-6.

3.8 Ethics approvals and safety considerations

Ethical approvals were sought for each strand of the multilevel mixed methods design. Permissions to use the HDSS in Ghana were granted by the Institutional Review Boards of the three research centres in Ghana and approval to access the Scottish maternal and neonatal linked database was granted by the then Privacy Advisory Committee (PAC) of the National Health Service, Scotland. Permissions to conduct questionnaire survey and in-depth interviews of maternity care providers were granted by the regional and district health management teams, after full ethics approval for the overall study in Ghana was given. All maternity care providers participating in the questionnaire and interview studies also gave their individual informed consent. Details of the ethics application processes are discussed in the respective chapters from 4-7.

Table 3.6.1: Characteristics of data used in multilevel mixed methods study

Stage	Source of data	Type of data	Population
2°QUAN	Navrongo Health Research Centre (NHRC), Ghana	Secondary quantitative data from Health and Demographic Surveillance System (HDSS)	Neonates and mothers in KNE district, Navrongo*
	Kintampo Health Research Centre (KHRC), Ghana		Neonates and mothers in Kintampo north and south, Kintampo
	Dodowa Health Research Centre (DHRC), Ghana		Neonates and mothers in SOD and NP district, Dodowa
	Information services Department (ISD), Scotland	Secondary quantitative data from the Scottish morbidity record and Scottish stillbirths and infant death register	Neonates and mothers in Scotland
1°QUAN	Questionnaire survey	Primary quantitative data of newborn care practices and health care related factors	Maternity care providers within Navrongo, Kintampo and Dodowa
qual	In-depth interview	Qualitative data of birth practices for adverse neonatal outcomes	Maternity care providers in Navrongo, Kintampo and Dodowa who experienced asphyxia, prematurity, infection or neonatal death
*The NHRC covers the Kassena Nankana East and West districts but data were provided for Kassena Nankana East only			
KNE-Kassena Nankana East			
NP-Ningo Prampram district			
SOD-Shai Osudoku District			

The secondary data were managed according to the conditions of the ethics approvals and policies of the holding organisations. Audio records on the recorder were erased after they were copied onto a computer with password protection. Data (audio and textual) from interviews will be stored securely by 2 years following last publication in accordance with International Committee of Medical Journal Editors Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals (209). After this period, the electronic data will be deleted and the paper copies shredded. Data will not be shared with a third party without appropriate authorisation.

Chapter 4 Neonatal Mortality in three Health and Demographic Surveillance System areas in Ghana

4.1 Introduction

This chapter presents the methods employed in the health and demographic surveillance system (HDSS) in three regions of Ghana, and the results from analyses of these HDSS data. These routine data were provided by the three health research centres (HRC) in Ghana: Navrongo health research centre (NHRC), Kintampo health research centre (KHRC), and Dodowa health research centre (DHRC). The aims of the analyses were to;

a. Determine and compare the NMRs in three regions of Ghana
b. Determine whether the NMRs in these regions have changed over time
c. Determine the distribution of neonatal deaths by time and cause of death
d. Determine the factors associated with neonatal mortality in Ghana.

The analyses of the HDSS data represent the 2^{o}QUAN phase of the overall multilevel mixed methods design, described in chapter 3.

4.2 Methods

4.2.1 Methods for the health and demographic surveillance system

In all three HDSS areas, unique ID numbers are assigned to every household and their respective members. Trained field workers visit all registered households regularly – every four months in Navrongo and every six months in Kintampo and Dodowa - to collect key health and socio-demographic information. The field workers interview the heads of the household, or another eligible adult, using the compound or household registration book, which contains primary information about all members in the household. Where a new event is recorded, the compound/household registration book is updated. In addition, key events, defined as births, deaths, migration and pregnancies, which happen between the field worker visit times are reported by community key informants, who have received suitable training (for a fee) after the event is confirmed by a field supervisor (19, 20, 210). Information on pregnancies and births is recorded using the pregnancy registration form and birth registration form respectively.

Within six months after a death occurs, allowing sufficient time for mourning, a field supervisor visits the affected household and interviews the immediate caregiver of the deceased or other informant, using the verbal autopsy (VA) questionnaire. The VA questionnaire is a tool for determining the probable cause of death in settings with no or incomplete vital registers or where the events leading to the death were not observed within a health care facility (211). Developed by WHO (212), the VA questionnaire uses techniques based on caregiver recall and includes a checklist of signs and symptoms, and a narrative of events preceding death. Following its revision in 2012, the VA questionnaire has been adapted by many countries, especially in Africa and Asia (213, 214). Detail about the background, content and usage of the VA has been published (212). There are many validation studies that support its widespread use as an accurate tool to determine cause of death, especially for neonatal deaths in countries with high rates including Ghana, Nigeria Pakistan, Vietnam and India (59, 211, 215, 216). In Ghana, a prospective study assessing the diagnostic accuracy of VAs found that approximately 70% of the referenced neonatal deaths were correctly classified by the VA questionnaire, and sensitivity was >70% for all major causes of death except prematurity (64%). Specificity was 76% for birth asphyxia and >85% for prematurity and infection (59). Similar findings have been reported earlier in Pakistan (215) and Vietnam (216).

In the case of a neonatal death, a special neonatal VA questionnaire is used. Information collected includes a structured checklist of signs and symptoms and an open-ended section for a narrative of all events that preceded the death of the baby. These VA questionnaires are returned to the field office for cross checking for inconsistencies and missing data. They are then dispatched in batches of 50 for entry into the Information System and Data Processing Unit. Batch numbers and unique identification numbers are generated for each questionnaire for easy identification and tracking. Coding forms are then generated for each questionnaire and handed over to individual clinicians to code for probable cause of death based on the narrative and checklist in the VA questionnaire. The clinician’s procedures for coding the VA questionnaires are guided by the VA manual of the International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH) Network Mortality Classification list, which contains the list of probable causes of death based on

WHO ICD-10 (20). Each VA questionnaire is coded independently by two clinicians. Where there is disagreement in the cause of death assigned by the two clinicians, a third opinion is sought from a third clinician. If the third clinician agrees with the first or second, that will be the assigned code. Where all three clinicians assign a different cause of death, a coding conference is organised for the three clinicians to re-consider the VA questionnaire and agree on a common cause of death. Data quality in the HDSS is assessed by the field supervisors who do on-site quality checks by cross-checking any queries from the data processing unit.

4.2.2 HDSS data management

I obtained an electronic extract of the HDSS data, comprising information from the birth registration forms and the standard neonatal VA questionnaires, from each of the three HRCs in Ghana. The birth registration forms contained information on all babies delivered in the surveillance area and the neonatal VA files contained extra information on babies who died within 28 days after birth within the same period. Data from Navrongo covered the years 2004 to 2012, from Kintampo 2005 to 2010 and from Dodowa 2006 to 2014. These data were stored in a relational database designed using Visual FoxPro version 5 but also convertible to other statistical software package formats. The relevant variables for the current study were extracted by experienced data managers in each HRC and converted to a Stata compatible format. I received the datasets via a secured server and then stored them on an encrypted drive from which all data management and statistical analyses were carried out, in accordance with the ethical approval (section 5.2.3).

Although the HDSSs were set up to collect similar data across Ghana and are thus similar in many ways- purpose and method of data collection- they were also unique in some respects. The birth registration questionnaires from each research centre, for example, did not collect the same number of variables and common variables may not have the same number of categories or values assigned. The main exposure variable in this study, place of delivery for example, was recorded as five categories in the Navrongo HDSS, seven categories in the Kintampo HDSS and eight categories in the Dodowa HDSS. Data from each research centre were therefore, cleaned, renamed, and recoded separately to ensure common variables were assigned similar numbers and types of categories and values. Detailed descriptions of the variables included in this study and how they were recoded are contained in section 5.2.4.

The Navrongo HDSS data were released as a single zipped file- the VA and birth registration files were merged by the centre's data managers before release. The Kintampo HDSS data were released as two separate files for the birth registration and neonatal VA file and the Dodowa HDSS data were in three separate files- birth registration, pregnancy outcome and neonatal VA files. The Kintampo and Dodowa HDSS datasets therefore needed to be merged into separate single files for the respective surveillance areas. The data management procedures, including data cleaning and merging, for each region have been discussed under the relevant section in this chapter.

4.2.3 Ethics approval

Permissions to access maternal and neonatal data from the HDSS were granted by the respective HRC that managed the data. These three HRCs are part of the Ghana Health Service, with a mandate from the Ministry of Health, Ghana to maintain the demographic surveillance systems and provide a platform for investigation into health problems. Each research centre has an institutional review board (IRB), or ethics review committee, to ensure the safety and wellbeing of research participants and consider the ethical merits of health research carried out within its jurisdiction. Formerly, the IRBs considered it sufficient to obtain verbal consent from the household head or any other adult member of a household to update the health and demographic information. However, since 2011, written consent has been required before conducting verbal autopsies.

Authorisations to obtain and use relevant extracts of the HDSS data were sought using the procedures required by each centre's IRB. Generally, all three research centres required an independent ethics application with supporting documents; a written application for ethics approval from me and a letter of support from each research supervisor, my curriculum vitae and that of my supervisors, a detailed research proposal with relevant data collection instruments and an analyses plan and a protocol submission checklist. The total administrative charge for the three ethics applications was less than £400, and there was no additional cost for accessing and using the HDSS data.

Following three independent ethics approvals for the safety and ethical nature of the study by the NHRC, KHRC and DHRC, a three-member committee of the Directors of the research centres and chaired by the Director of NHRC was set up to discuss the terms for releasing relevant extracts of the HDSS data. Permission for the commencement of data extraction and subsequent sharing of data was given after the terms for releasing data were considered ethical and satisfactory by the committee. It was agreed that the research would be conducted as a collaboration between the three HRCs in Ghana and the Institute of Health and Wellbeing, University of Glasgow. Most of these discussions were verbal, and rarely email, as the Directors were reluctant to sign a binding document given experiences of non-adherence on the part of previous principal investigators. This is the first collaboration between the University of Glasgow and the HRCs.

The terms for collaboration permitted the following;

a. I would receive an extract of HDSS data (zipped file), relevant to the current study, from the HRCs in Ghana via a secured server.
b. The data would be downloaded and stored on a password protected hard drive from which all analyses would be carried under the supervision of my supervisors at the University of Glasgow.
c. I would receive necessary clarifications and support regarding the HDSS data from data managers in the various HRCs.
d. Collection of additional primary data from health care providers in the research centres' surveillance areas would be supervised by the Directors of the respective health research centres.
e. Due recognition would be given to each institution and individuals for their contributions.
f. Copies of reports and publications from the project would be sent to relevant stakeholders.

4.2.4 Definition of variables

All the variables in the pregnancy outcome file, birth registration form, and VA file, except cause of death, were self-reported. The list of variables from the HDSS with their definitions and how they were coded is given below.

1. *Place of delivery*: Refers to the setting in which the baby was reported to have been delivered. This was classified into three categories: hospital, clinic and home births. Hospitals were formal facilities with a midwife or nurse and a doctor. Clinics were formal facilities with either a midwife or nurse, but no doctor. Hospital and clinic births were collectively termed institutional birth or facility birth. They included health centres, community-based health planning services (CHPS) and maternity homes. Home births included babies delivered in either the TBA's home or the mother's home, with no formally trained midwife or doctor. Hospital and clinic births were collectively termed institutional or facility birth. Mothers delivered in settings classified as 'other', or were delivered on the way to a clinic or hospital was excluded from the study. Place of delivery was the main exposure variable in this study.
2. *Neonatal death*: Neonatal mortality was the main outcome variable in the current study. It was dichotomised as Dead or Alive. A baby was considered dead if he/she died within 28 days of birth (days 0-27) and was classified alive if he/she did not die within the study period or died after 28 days of birth. Deaths within seven days of birth (days 0-6) were classified as early neonatal deaths (END) and deaths after seven days (days 7-27) were considered late neonatal deaths (LND) (217). The END were further classified into deaths on the day of birth (Day 0) and deaths which occurred in 1-6 days.
3. *Socioeconomic status*: Data on socioeconomic status were provided as five quintiles for the study population: poor, next poor, average, next rich and rich. These categories were derived by statisticians at the research centre from principal component analyses (PCA) of household assets; type of housing, roofing and flooring material, structural condition of house, number of rooms, status of occupancy, electricity supply, type of cooking fuel, household facilities, source of water, health insurance enrolment status, land ownership and utilisation, type of assets in working

conditions, income per week or month of household head and other income earners in the household, type of cooking salt, livestock and number of leave days. Information on household assets is ascertained from the household head and updated annually. Further detail about the calculation methods has been previously published elsewhere (218, 219).

4. *Marital status*: Marital status was dichotomised as married or not married. Marital status was not recorded in Kintampo.
5. *Maternal age*: Mothers age at delivery was calculated as the difference between baby's year of birth and mother's year of birth. Mothers calculated as younger than 13 years old or older than 60 years were treated as missing.
6. *Education*: Education referred to the highest level of formal education attained by the mother at the time of delivery. This was categorised as "no education", "basic education" and "secondary or more education". No education referred to a mother who had received no form of formal education or schooling. Basic education referred to a mother who had attained up to junior high education. Secondary or more education referred to a mother who had received secondary education or higher.
7. *Ethnicity*: Ethnicity referred to the tribe to which the mother said she belonged.
8. *Religion:* Religion referred to the religious denomination to which the mother said she belonged.
9. *Occupation*: Occupation referred to the main means of livelihood a mother said she engaged in.
10. *Antenatal care* (ANC) attendance: ANC attendance was classified as Yes or No, depending on whether a mother received at least one episode of ANC during pregnancy. This was recorded retrospectively after delivery, based on maternal recall. In Dodowa, it was not recorded before 2011 and in Navrongo it was not recorded before 2012.
11. *Number of ANC visits*: The number of ANC visits referred to the number of times a mother received ANC before delivery. This was categorised into 1, 2, 3 and 4 or more in accordance with the WHO recommendation (http://www.who.int/gho/urban_health/services/antenatal_care_text/en/. Women who did not attend ANC, therefore, had 0 number of visits.

12. *Booking visit*: Booking visit refer to the first time a woman received ANC. It was classified according to the trimester during which she first received ANC (*Booking visit*=0 if *ANC attendance*=No).
13. *Multiple births*: Multiple births refer to a mother who delivered more than one baby at the end of a single pregnancy. It was dichotomised into singletons and multiple, for twins or more. If multiple births were recorded as more than 4, it was treated as a missing value.
14. *First birth*: First birth was derived from the birth order of the baby. This was dichotomised as Yes or No, if the baby was the first born or not respectively.
15. *Parity*: Parity refers to the total number of live births a woman had delivered, including the current birth, at the time of data collection. It was categorised into 1, 2, 3 and 4 or more, and the value was cross-checked with *first birth* for consistency (*Parity*=1 if *first birth*=Yes; *Parity*>1 if *first birth*=No). If *parity* was greater than 1 and *first birth*=Yes, the value of *parity* was treated as missing based on the advise of demographers at the HRC.
16. *Sex*: Sex was categorised as male or female.
17. *Day of birth*: Refers to the day of the week in which a baby was born. It was generated from the baby's date of birth and categorised as weekend if a baby was born on Saturday or Sunday, and weekday if he or she was born from Monday to Friday inclusive.
18. *Staff at delivery*: Refers to the maternity care provider who assisted the delivery of the baby as reported by the mother.
19. *Mode of delivery*: Refers to the means by which a baby was delivered. It was categorised into vaginal delivery, assisted delivery (vacuum delivery or forceps delivery) and caesarean section.
20. *Age at death*: Age at death was calculated as the difference, in days, between date of birth and date of death. It was categorised into 0 (deaths on the day of birth), 1-6 (early neonatal deaths, excluding deaths on the day of birth) and 7-27 days (late neonatal deaths).
21. *Cause of death*: Refers to the most probable cause of neonatal death as ascertained by at least two medical doctors from the VA narrative and checklist.

4.2.5 Statistical analyses

All statistical analyses were conducted using Stata version 14SE (StataCorp, Texas, USA) and statistical significance was set at 5% ($p<0.05$). The analyses were stratified by region and place of delivery.

4.2.5.1 Descriptive statistics: HDSS data from each region were described according to the maternal, delivery and neonatal characteristics, by place of delivery and neonatal mortality. Frequencies and column percentages were used to summarise the various explanatory variables and p-values showed statistically significant differences in the variables. The number of missing data for each variable was also recorded but excluded from the calculation of column percentages and test of statistical significance. Line graphs were used to depict temporal trends in NMRs and moving average NMRs in each region, overall and by place of delivery, and bar graphs used to present the causes for neonatal deaths.

Pearson's chi square test was used to test statistically significant differences between categorical exposure variables (place of delivery, sex, ANC visits, multiple birth, first birth and day of birth, marital status, occupation, religion) by place of delivery and neonatal mortality. Significant differences between education, maternal age, socioeconomic status, parity, number of ANC visits, booking visit and year of birth, by place of delivery and neonatal mortality were assessed using Kruskal-Wallis test and chi square test for trends.

4.2.5.2 Inferential statistics: Binary logistic regression models were used to explore the associations between maternal, delivery and neonatal characteristics and neonatal mortality (dead or alive), overall and stratified by place of birth. Logistic regression analyses were used because the outcomes variable was binary. The associations between explanatory variables and the binary outcome were first analysed using univariate models to produce unadjusted estimates. A multivariable logistic regression analysis was then conducted, overall and stratified by place of delivery, to adjust for confounding variables and observe whether associations were independent of each other. The variables included in the multivariable models varied between regions, depending on which variables were collected or provided by each research centre. Details of these are described in the respective sections for each region. A Hosmer-Lameshow test was used to check the goodness of fit.

The logistic regression models were fitted using standard maximum likelihood estimates. Where maximum likelihood estimates for binary logistic regression were likely to yield biased estimates due to empty cells, or could not be estimated due to 'separation', a penalised maximum likelihood regression [*firthlogit*] was used to fit the regression model (220, 221). The standard errors for the multivariable model were based on cluster robust standard errors to take into account the possible effect of clustering at the level of place of delivery because babies delivered in a similar type of facility were more likely to be similar. Likelihood ratio tests for statistical interactions by maternal age, socioeconomic status, parity and year of birth were conducted, and where results were found to be significant, appropriate subgroup analyses were conducted. In addition, further sub group analyses were conducted to explore the risks for early and late neonatal deaths- according to babies who died on the day of birth (day 0), those who died from days 1-6 and babies who died in the late neonatal period (days 7-27).

4.2.5.3 Missing data: In this thesis, missing data were analysed using multiple imputation (MI) techniques. Missing data is a common problem in all epidemiological studies and the pattern of missingness has implications for the statistical techniques used. The datasets provided by each research centre contained large numbers of missing data for some variables (Table 4.2.1). There were two major sources of missing data in the HDSS datasets; missing within regions and missing between the regions. Within each region, a fraction of some variables was missing simply because the value was not assigned or not known. Secondly, variables that did not corroborate were categorised as missing. For example, if a mother indicated that the recorded birth was her first (*first birth*) but subsequently reported to have more than one child (*parity*), the value for parity for that baby was treated as missing. The data managers and demographers recommended that the latter variable be treated as missing because of issues regarding the data quality for count variables. Thirdly, non-feasible values of a variable were treated as missing. For example, maternal ages less than 13 years or greater than 60 years or mothers who indicated they gave birth to more than four babies at a single delivery episode. The patterns of the missing variables in each HDSS dataset were explored to ensure there were no obvious patterns or trend. Missingness was therefore treated as missing at random.

There were some differences in the variables collected between each research centre (region). Table 4.2.1 summarises variables recorded by each region and the proportions of missing values. It shows that some variables were collected in only one or two regions. Maternal education, for example, was recorded in Navrongo and Dodowa but not in Kintampo. This implies that the value for maternal education was missing for the whole of Kintampo. There were also differences in how some of the variables were measured in each region. Socioeconomic status, for example, was measured as quintiles within each region. It was thus possible for a woman in Navrongo to be classified as rich whilst the same woman might be classified average or lower in Dodowa. There were also potential differences in the distribution of the recorded variables across the three regions. For these reasons, the HDSS data were imputed by region.

Table 4.2.1: Summary of missing data by region

Variable	Navrongo (N=17,016)	Kintampo (N=11,207)	Dodowa (N=21,647)
Mortality	0	0	0
Place of birth	0	0	0
Sex	0	0	0
Day of birth	0	0	0
Year of birth	0	0	0
Multiple birth	6	126 (1.1)	0
Maternal age (years)	0	43 (0.4)	49 (0.3)
Socioeconomic status	1,117 (6.6)	32 (0.3)	0
Marital status	0	-	428 (2.0)
Education	382 (2.2)	-	5 (0.02)
Ethnicity	-	-	13 (0.1)
Religion	-	-	18 (0.1)
Occupation	-	-	5 (0.02)
ANC visits	16,020 (94.2)	1,824 (16.3)	11,491 (53.1)
Booking visit	-	-	11,518 (53.2)
Number of ANC visit	-	-	11,734 (54.2)
First birth	0	15 (0.1)	9 (0.04)
Parity	194	243 (2.2)	4,234 (19.5)
Personnel at delivery	10,083 (59.3)	-	11,487 (53.1)
Mode of delivery	16,003 (94.0)	-	-
Instrument to cut cord	117 (0.7)	-	-

-variable not collected 0=No missing data (complete cases)

4.2.5.4 Multiple imputations by chained equations

Multiple imputation (MI) is a simulation based statistical technique for handling missing data whereby several copies of the original dataset, each containing different possible values for the missing variable, are created using complex stochastic methods. The primary idea underlying MI is to predict a set of plausible values for the missing data, using the distribution of the observed data. MI also incorporates a random measure of uncertainty to estimate the true value (222). This makes MI techniques more theoretically sound and yield more accurate results (223) than other deletion methods (For example Listwise or Pairwise deletion methods) which reduce the sample size, or single imputation techniques which yield smaller standard errors (For example mean or mode substitution or dummy variable method).

Multiple imputation techniques were conducted using Stata's imputations by chained equations (ICE). ICE algorithms were used because they do not assume a joint multivariate normal distribution but, rather, allow the conditional distribution of each variable to be imputed to be specified. This was particularly useful because the explanatory variables being imputed in the current model included a combination of count data (parity), binary variables (ANC, sex), and ordinal variables (socioeconomic status). The number of imputations generated was based on the fraction of missing information as recommended by Graham, Olchowski and Gilreath (224).

Many authors describe the 'three phases of MI' as follows (Multiple Imputation Reference Manual, StataCorp, Texas, (222, 225, 226);

a. Imputation: modelling, iteration and creating multiple datasets.
b. Analyses: determining parameter estimates for each single dataset.
c. Pooling: determining the average of parameter estimates from each dataset in *b*, taking into account the standard error of each estimate from each imputed dataset.

These three phases of MI and their applicability in the current thesis are explained below, but additional details can be found elsewhere (227, 228)

***Imputation**:* Imputation refers to the creation of multiple datasets with each dataset containing different possible values for the missing variable. The imputation phase begins with determining the probability method or the regression model for predicting the missing data. This modelling step has been described as the 'most difficult' step of the MI technique (225). The regression model predicts, or imputes, an estimated value for the missing data from a posterior predictive distribution of the missing data using a switching regression. These predictions incorporate a random error to maintain variability within the imputed dataset and also show the uncertainty with the predictions (226). This is followed by an automated iteration process whereby the imputation phase is repeated over a number of cycles, *n*, and then the subsequent dataset created after the *nth* iteration is saved. The iteration process is important to ensure that the imputed datasets are independent of each other.

The variables included in the imputation model for each region were similar to those used in the multivariable logistic regression model for complete cases. In addition, all other variables which were related to the outcome were included in the imputation model, even if they were not included in the multivariable regression model. Stata's automated augmentation methods for imputations were used to impute variables which would otherwise have been 'perfectly predicted' (229). The specific variables used to impute each HDSS data have been described in the relevant section.

There seems to be a consensus among statisticians today that the former advice that 3-5 imputations were sufficient to provide excellent results (228) is no longer acceptable and many have called for an increase in the number of imputations created (224, 230). Simulation studies suggest that models with higher number of imputations, *m*, have the advantage of increased power and yield more efficient results (224). To my knowledge, there is no published paper that states an upper boundary for the number of imputations required, and some have suggested a theoretical infinity (224). A general rule of thumb has been suggested that "the number of imputations should be similar to the percentage of cases that are incomplete" (222, 230). In this thesis, the number of imputations for each model was based on the variable with the highest fraction of missing information (FMI) for each imputation model. For example, if the FMI for a model was 0.62, then 62 imputations were created. The final imputation model for the overall multivariable model was also based on cluster robust standard errors to account for the effects of clustering in the data.

Analyses: The next phase of the MI process is to run the analytical model of interest on each of the imputed datasets to generate parameter estimates and standard errors. This analytical model runs on each imputed dataset as though they were independent complete datasets. The dependent variable in this thesis, neonatal mortality, was a binary variable (dead or alive) and therefore the analytical model was based on a binary logistic regression that reported odds ratios (OR), and also allowed for adjustment of potential confounding variables.

Pooling: The parameter estimates and the standard errors calculated from each imputed dataset, including the original dataset, are then averaged into a single estimate. This pooled estimate is simply the arithmetic mean of the estimates from each single dataset, although the average for the standard errors uses a more complicated procedure- 'Rubins rule' (226). The analyses and pooling phases of the multiple imputations are all automated and thus there is no need for manual computations. The parameter estimates from the multivariable logistic regression model were thus adjusted odds ratios, with their corresponding unadjusted univariate estimates.

4.3 The Navrongo health and demographic surveillance system

This section describes and discusses the methods and results of the Navrongo HDSS.

4.3.1 Navrongo HDSS data management

An electronic extract of the Navrongo HDSS was released in a Stata (.dta) format. Variables contained in the dataset were renamed and recoded to make them consistent with the data extracted from Kintampo (section 4.4) and Dodowa (section 4.5); reducing variables to the lowest level of precision where this varied between regions. For example, the baby's place of delivery was re-categorised into hospital, clinic or home deliveries by combining all the clinic options collected by Navrongo: health centres, CHPS and clinics. The distribution of the characteristics of babies and mothers is summarised in Tables 4.3.1-2.

4.3.2 Statistical analyses

Detail of the methods used for descriptive and analytical statistics, including multiple imputations, have been described previously in 4.2.5. In summary, maternal, neonatal and delivery related factors were tabulated by place of delivery (Table 4.3.1) and neonatal mortality (Table 4.3.2), and line graphs were used to depict the temporal trends in neonatal mortality rate from 2004-2012 (Fig 4.3.1) and a moving average NMR (Fig 4.3.2), overall and by place of delivery. Univariate and multivariable binary logistic regression models were used to explore the associations between maternal, delivery and neonatal characteristics and neonatal mortality (dead or alive) and the magnitude of those associations, overall and stratified by place of birth (Tables 4.3.4-5).

The multivariable models were adjusted for the following potential confounders; maternal age, socioeconomic status, education, marital status, sex of the baby, year of birth, twin birth, parity, day of birth and year of birth. Variables for the instrument used to cut the cord and personnel who conducted the delivery were excluded from the multivariable model because they were highly correlated (>75%) with place of delivery; 'first birth' was also excluded from the multivariable model because it was strongly correlated with parity (80%). When the ROC curve, AIC and BIC statistics for the two regression models- one containing parity and the other first birth- were compared, the model containing parity was shown to explain the association between the explanatory variables and neonatal mortality better. ANC attendance and mode of delivery could not be included in the multivariable models because information was available on babies delivered in 2012 only.

The complete dataset had approximately 10% of data missing. Multiple imputation (MI) techniques were, therefore, used to simulate possible values for each missing datum using Stata's imputations by chained equations (ICE) algorithms which allowed the conditional distribution of each variable to be specified. The imputation model is given as: [ice NM pob m_age sex dob m_status educ (*ologit*) ses (*ologit*) parity (*ologit*) m_birth (*logit*) year (*mlogit*)]. Based on the highest fraction of missing information, FMI (socioeconomic status)=0.493, 50 imputations were created. Univariate and multivariable logistic regression analyses were undertaken to investigate the risks for neonatal mortality (dead/alive) (Tables 4.3.6-7).

The multivariable logistic regression models excluded data for the years 2004 and 2005 because the socioeconomic status of the mother did not appear to be missing at random for those years: dead babies were more likely not to have socioeconomic status reported compared to babies who did not die. In 2004, the proportion of missing data for dead babies was 97% compared to only 7% for babies who lived; in 2005 the proportion of missing socioeconomic data for dead babies was 76% compared to 10% of babies who lived. All other missing data for the subsequent years did not appear to be related to the outcome- assumed to be missing at random. Excluding data for the years 2004 and 2005 from the multivariable analyses reduced the sample size of the complete cases from 15,380 to 12,138, but it satisfied the missing at random condition for multiple imputations and produced more robust results.

Statistical interactions were tested between place of delivery and parity, education, socioeconomic status and maternal age. Results were found to be statistically significant and subgroup analyses were then conducted (Table 4.3.8). Further subgroup analyses were conducted to explore the risks for early and late neonatal deaths- according to babies who died on the day of birth (day 0), those who died from days 1-6 and babies who died in the late neonatal period (days 7-27).

4.3.3 Results- All births

Overall, 17,153 babies were born in the Navrongo HDSS from 2004 to 2012. After excluding babies whose place of delivery was unknown (n=3) and or was not specified (n=137), the final sample contained 17,016 babies. The results presented in this section are based on analyses of these 17,016 babies, unless otherwise indicated.

4.3.3.1 Summary characteristics of mothers and babies in Navrongo by place of delivery

Table 4.3.1 summarises the characteristics of mothers and babies who delivered in the Navrongo HDSS from 2004 to 2012, by place of birth. The results show that overall, 7,306 (42%) of the babies delivered in Navrongo were born in a hospital, 2,708 (15.9%) were born in a clinic and 7,002 (41.1%) were born at home. Mothers in the Navrongo HDSS were most frequently 20-29 years old, married and had attained at least basic education. It is clear from the table that mothers aged 20-29 years, next rich or rich, not married and had completed at least secondary education were more likely to deliver in hospitals. Teenage mothers and those who had completed only basic education were more likely to deliver in clinic and mothers over 30 years old, were classified from poor to average, married and those with no education were more likely to deliver at home.

A higher proportion of babies delivered in hospital was multiple births, first or second births and was delivered on weekends. Babies who were delivered in clinics were more likely to be singletons and delivered on a weekday. Higher proportions of babies who were delivered at home were girls and were delivered by a TBA, the mother's relative or friend or by other personnel. Women who attended ANC were more likely to deliver in hospitals and those who did not attend any episode of ANC were more likely to deliver in clinics or at home. The majority of women delivered at home from 2004-2008, but the proportion declined after that and the majority of women delivered in hospital after 2009.

Table 4.3.1: Summary of maternal and neonatal characteristics by place of delivery (Navrongo)

	Hospital (n=7,306) n (%)	Clinic (n=2,708) n (%)	Home (n=7,002) n (%)	Total (N=17,016) n (%)	p-value
Neonatal mortality					
Alive	7,156 (98.0)	2,677 (98.9)	6,863 (98.0)	16,696 (98.1)	0.01
Dead	150 (2.1)	31 (1.1)	139 (2.0)	320 (1.9)	
Maternal age					
<20 years	858 (11.7)	339 (12.5)	678 (9.7)	1,875 (11.0)	<0.001
20-29	3,899 (53.4)	1,347 (49.7)	3,111 (44.4)	8,357 (49.1)	
30-39	2,130 (29.2)	776 (28.7)	2,323 (33.2)	5,229 (30.7)	
40+	419 (5.7)	246 (9.1)	890 (12.7)	1,555 (9.1)	
Socioeconomic status					
Poor	856 (12.7)	782 (30.7)	2,217 (33.5)	3,855 (24.5)	<0.001
Next poor	808 (12.0)	523 (20.6)	1,585 (24.0)	2,916 (18.3)	
Average	964 (14.3)	467 (18.4)	1,346 (20.3)	2,777 (17.5)	
Next rich	1,516 (22.5)	474 (18.6)	1,215 (18.4)	3,205 (20.2)	
Rich	2,591 (38.5)	299 (11.8)	256 (3.9)	3,146 (19.8)	
Missing	571	163	383	1,117	
Marital status					
Not married	1,494 (20.5)	412 (15.2)	830 (11.9)	2,736 (16.1)	<0.001
Married	5,812 (79.6)	2,296 (84.8)	6,172 (88.2)	14,280 (83.9)	
Education					
None	1,222 (17.2)	823 (31.5)	2,881 (41.6)	4,926 (29.6)	<0.001
Basic	3,784 (53.3)	1,509 (57.8)	3,733 (53.9)	9,026 (54.3)	
Secondary+	2,089 (29.4)	280 (10.7)	313 (4.5)	2,682 (16.1)	
Missing	211	96	75	382	
Instrument to cut cord					
New razor	302 (4.2)	147 (5.5)	6,631 (94.8)	7,080 (41.9)	<0.001
Old razor/knife	129 (1.8)	89 (3.3)	44 (0.6)	262 (1.6)	
Scissors	6,767 (93.8)	2,450 (91.0)	257 (3.6)	9,474 (56.1)	
Other	14 (0.2)	6 (0.2)	63 (0.9)	83 (0.5)	
Missing	94	16	7	117	
Sex					
Female	3,561 (48.7)	1,322 (48.8)	3,572 (51.0)	8,455 (49.7)	0.02
Male	3,745 (51.3)	1,386 (51.2)	3,430 (49.0)	8,561 (50.3)	
First birth					
No	4,612 (63.1)	1,902 (70.2)	5,618 (80.2)	12,132 (71.3)	<0.001
Yes	2,694 (36.9)	806 (29.8)	1,384 (19.8)	4,884 (28.7)	
Parity					
1	2,694 (37.3)	806 (30.1)	1,384 (20.0)	4,884 (29.0)	<0.001
2	1,755 (24.3)	541 (20.2)	1,343 (19.4)	3,639 (21.6)	
3	1,266 (17.5)	498 (18.6)	1,350 (19.5)	3,114 (18.5)	
4+	1,503 (20.8)	832 (31.1)	2,850 (41.1)	5,185 (30.8)	
Missing	88	31	75	194	
Multiple birth					
Single	7,010 (96.0)	2,626 (97.0)	6,760 (96.6)	16,396 (96.4)	0.02
Multiple	296 (4.1)	81 (3.0)	237 (3.4)	614 (3.6)	
Missing	0	1	5	6	
Day of birth					
Weekday	5,158 (70.6)	2,026 (74.8)	4,965 (70.9)	12,149 (71.4)	<0.001
Weekend	2,148 (29.4)	682 (25.2)	2,037 (29.1)	4,867 (28.6)	

4.3.3.2 Neonatal mortality and neonatal mortality rate in Navrongo

Of the 17,016 babies born alive in the Navrongo HDSS 2004-2012, 320 died within 28 days. The overall NMR was thus 18.8. This represents a NMR of 20.5 for babies delivered in hospitals, 11.4 for clinic births and 19.9 for those born at home and the differences in NMR by place of delivery was statistically significant. The table also shows statistically significant differences in NMR by marital status of the mother, sex of the baby, first birth, parity and multiple births. Babies born to unmarried mothers, boys, twins and first births were more likely to die in the neonatal period. Twins had the highest NMR of 71.7 (compared to singletons NMR=16.8) and boys had significantly higher NMR (NMR=21.3) than girls (NMR=16.3). NMR did not differ significantly by maternal age, socioeconomic status or maternal education.

Table 4.3.2: Summary of maternal characteristics in Navrongo by neonatal death and mortality rate

	Total livebirths n (%)	Dead n (%)	NMR	p-value
Navrongo	17,016	320	18.8	-
Place of birth				
Hospital	7,306 (42.9)	150 (46.9)	20.5	0.01
Clinic	2,708 (15.9)	31 (9.7)	11.4	
Home	7,002 (41.1)	139 (43.4)	19.9	
Maternal age				
<20 years	1,875 (11.0)	52 (16.3)	27.7	0.07
20-29	8,357 (44.1)	141 (44.1)	16.9	
30-39	5,229 (30.7)	106 (33.1)	20.3	
40+	1,555 (9.1)	21 (6.6)	13.5	
Socioeconomic status				
Poor	3,855 (24.3)	61 (26.0)	15.8	0.34
Next poor	2,916 (18.3)	47 (20.0)	16.1	
Average	2,777 (17.5)	37 (15.7)	13.3	
Next rich	3,205 (20.2)	49 (20.9)	15.3	
Rich	3,146 (19.8)	41 (17.5)	13.0	
Missing	1,117	85		
Marital status				
Not married	2,736 (16.1)	65 (20.3)	23.8	0.04
Married	14,280 (83.9)	255 (79.7)	17.9	
Education				
None	4,926 (29.6)	99 (31.6)	20.1	0.11
Basic	9,026 (54.3)	176 (56.2)	19.5	
Secondary+	2,682 (16.1)	38 (12.1)	14.2	
Missing	382	7		
Instrument to cut cord				
New razor	7,080 (41.9)	138 (43.4)	19.5	0.17
Old razor/knife	262 (1.6)	3 (0.9)	11.5	
Scissors	9,474 (56.1)	173 (54.4)	18.3	
Other	83 (0.5)	4 (1.6)	48.2	
Missing	117	2		
Sex				
Female	8,455 (49.7)	138 (43.1)	16.3	0.02
Male	8,561 (50.3)	182 (56.9)	21.3	
First birth				
No	12,132 (71.3)	191 (59.7)	15.7	<0.001
Yes	4,884 (28.7)	129 (40.3)	26.4	
Parity				
1	4,884 (29.0)	129 (40.6)	26.4	<0.01
2	3,639 (21.6)	47 (14.8)	12.9	
3	3,114 (18.5)	54 (17.0)	17.3	
4+	5,185 (30.8)	88 (27.7)	17.0	
Missing	194	2		
Multiple birth				
Single	16,396 (96.4)	276 (86.3)	16.8	<0.001
Multiple	614 (3.6)	44 (13.8)	71.7	
Missing	6	0		
Day of birth				
Weekday	12,149 (71.4)	215 (67.2)	17.7	0.09
Weekend	4,867 (28.6)	105 (32.8)	21.6	

4.3.3.3 Temporal trends in neonatal mortality rates in Navrongo

This section describes the temporal trends in neonatal mortality in the Navrongo HDSS from 2004 to 2012, and a three-year moving average neonatal mortality rate, overall and by place of delivery.

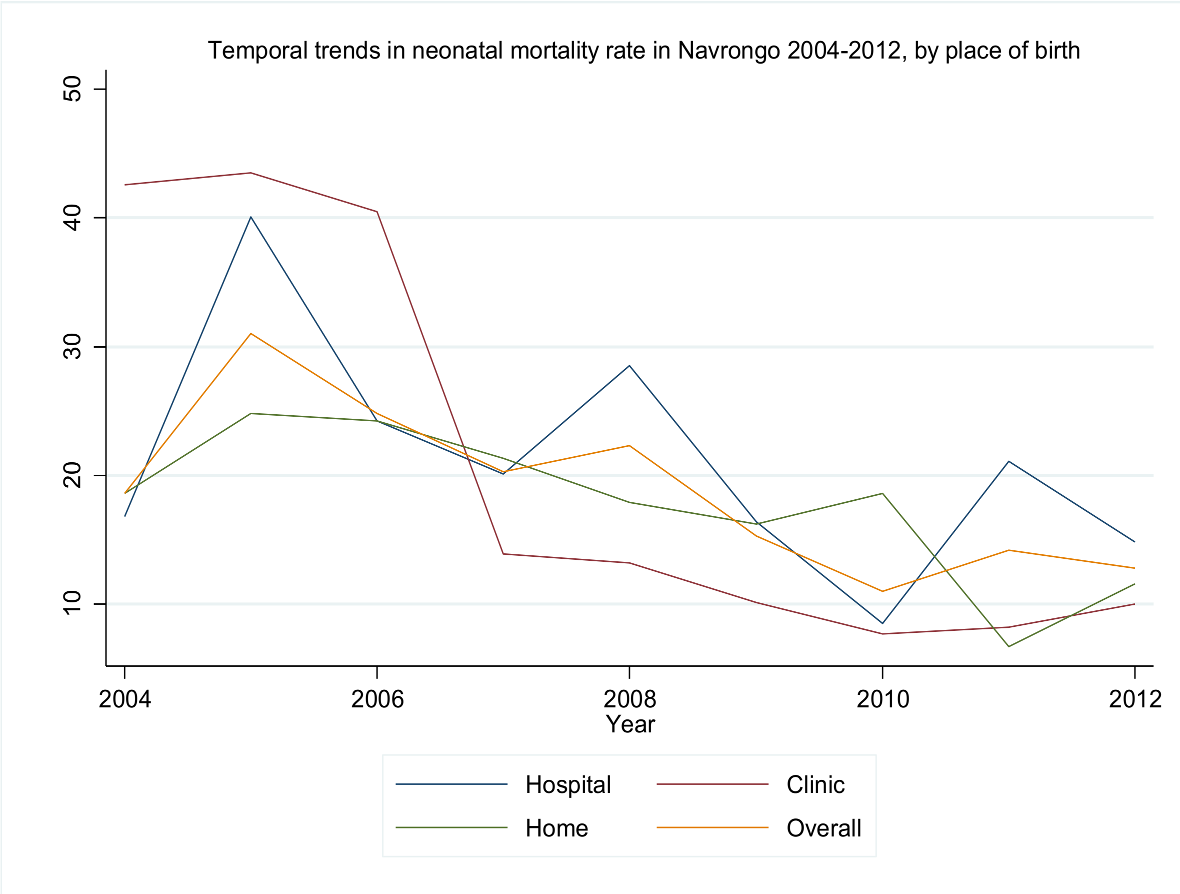


Fig 4.3.1: Temporal trends in neonatal mortality rate in Navrongo 2004-2012

Fig 4.3.1 depicts the temporal trends in NMR in Navrongo from 2004 to 2012, overall and by place of delivery. The line graph shows that, overall, NMR in Navrongo decreased by 31% (from 18.6 in 2004 to 12.8 in 2012). Among babies delivered in hospital, NMR appeared to have decreased over the period, but the rate of decline was inconsistent; characterised by peaks and troughs. In clinics, NMR dropped steeply from 42.6 in 2004 to 13.9 in 2007 and remained fairly constant thereafter. Among babies delivered at home, NMR dropped gradually from 18.6 in 2004 to 11.6 in 2012.

The table shown in Table 4.3.3 summarises the temporal trends in NMR in Navrongo by place of delivery. In addition, the table shows statistically significant differences in the temporal trends of mortality among all births and babies born in hospital and clinics. There was a significant decline in overall NMR after 2008. This corresponds to a decline in number of total livebirths at home and a gradual rise in clinic births increasing 15 fold over the whole period and a significant decline in NMR in clinics.

Table 4.3.3: Temporal trends in births, deaths and NMR

Year	Total livebirths	Dead	NMR	p-value
Overall				
2004	1,883	35	18.6	<0.001
2005	1,806	56	31.0	
2006	1,894	47	24.8	
2007	1,972	40	20.3	
2008	1,794	40	22.3	
2009	1,828	28	15.3	
2010	1,826	20	11.0	
2011	1,976	28	14.2	
2012	2,037	26	12.8	
Hospital				
2004	654	11	16.8	0.01
2005	673	27	40.1	
2006	661	16	24.2	
2007	747	15	20.1	
2008	806	23	28.5	
2009	915	15	16.4	
2010	823	7	8.5	
2011	946	20	21.1	
2012	1,081	16	14.8	
Clinic				
2004	47	2	42.6	<0.01
2005	46	2	43.5	
2006	74	3	40.5	
2007	144	2	13.9	
2008	151	2	13.2	
2009	297	3	10.1	
2010	520	4	7.7	
2011	732	6	8.2	
2012	697	7	10.0	
Home				
2004	1,182	22	18.6	0.08
2005	1,087	27	24.8	
2006	1,159	28	24.2	
2007	1,081	23	21.3	
2008	837	15	17.9	
2009	616	10	16.2	
2010	483	9	18.6	
2011	298	2	6.7	
2012	259	3	11.6	

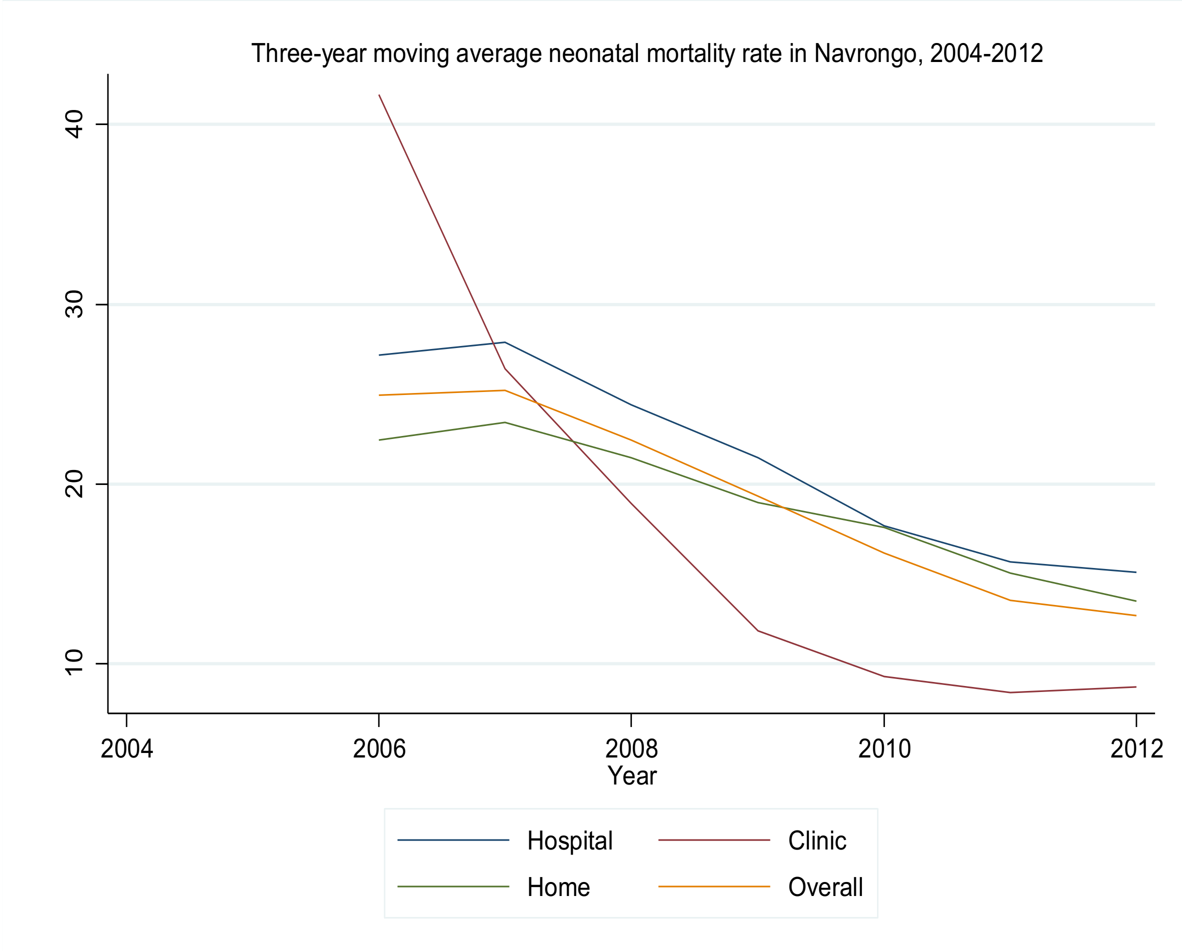


Fig 4.3.2: Three-year moving average of neonatal mortality rate in Navrongo

Fig 4.3.2 shows a three-year moving average neonatal mortality rate in Navrongo, overall and by place of delivery. The moving average neonatal mortality rate reduces the effect of year-to-year variability in the annual NMR. The line graph shows that NMR in the Navrongo HDSS has reduced considerably over the study period, both overall and by place of delivery.

4.3.3.4 Factors associated with neonatal mortality in Navrongo

This section presents the results of univariate and multivariable logistic regression analyses for the associations between maternal, delivery and neonatal characteristics and neonatal mortality in Navrongo, overall and by place of delivery.

Overall births

Univariate logistic regression analyses of the complete cases (Tables 4.3.4-5) and imputed data (Tables 4.3.6-7) suggested that in Navrongo, being born in a clinic was associated with a lower risk of neonatal death compared to babies born at home, but there was no statistically significant difference in NMR between babies delivered at home and hospital. Teenage mothers, unmarried mothers and first-time mothers were more likely to lose their babies in the neonatal period, and the risk of neonatal death decreased significantly with increasing parity. The univariate analyses also showed that boys, first births and twins were at a higher risk of neonatal death. The annual risk for neonatal death appeared to reduce monotonically over time, and did not interact with place of birth. Therefore, year of birth was included as a continuous variable (by quarter).

After adjusting for the measured confounding variables, the multivariable logistic regression of the complete cases (Table 4.3.5) showed that clinic births were associated with a significantly lower risk of death (adjusted OR 0.67, 95% CI 0.63-0.72) and hospital birth was associated with an increased risk of death (adjusted OR 1.08, 95% CI 1.02-1.14), compared to home births. Mothers aged 30-39 years had a higher risk of neonatal death but those over 40 years had a lower risk, compared to mothers aged 20-29 years. Twins had a much higher risk of death than singletons; babies of first time mothers and boys had a slightly higher risk of death compared to those of multiparous mothers and girls respectively. The risk of death also decreased with increasing maternal education and year of birth.

Multivariable logistic regression with imputed data (Table 4.3.7) showed that the factors related to overall NMR in Navrongo were place of delivery, maternal education, sex, parity, twins and year of birth. Overall, babies born in clinics had a 33% lower risk of death compared to babies born at home and babies born in hospital had a 14% increased risk of neonatal mortality. The risk of neonatal mortality decreased with increasing maternal education ($p<0.001$) and parity ($p=0.04$). Compared to mothers who completed basic education, babies born to mothers who had completed at least secondary education were 24% less likely to die in the neonatal period and those born to mothers who had not received any formal education were 12% more likely to die. Primiparous mothers had a higher risk of neonatal mortality than mothers with more than one child. Boys were 39% more likely than girls to die within 28 days of birth and twins were approximately five times more likely than singletons. The table also shows that the risk of death decreased by 3% for every year quarter. The age of the mother at the time of birth, socioeconomic status, marital status, and the day of birth of the baby were not associated with neonatal mortality, overall. The area under the ROC curve for the logistic regression model for complete cases was 68% (63%-71%) showing a moderate strength of the model. A Hosmer-Lameshow test to check the goodness of fit produced non-significant results at varying degrees of freedom, indicative of a good fit.

Subgroup analyses were conducted for the association between place of birth and neonatal mortality, by socioeconomic status, maternal age, parity and education because tests for statistical interactions were significant (Table 4.3.8). The results showed that the overall lower risk of neonatal mortality among babies born in clinics compared to those born at home was not significant for older mothers (40 years and above), those with at least secondary education and those with 2 or 3 children. The overall higher risk of neonatal mortality among babies who were born in hospital was significant for mothers 30-39 years old, poor or average socioeconomic status and those with no education. Further subgroup analyses, according to the age of the baby at death (Fig 4.3.3), showed that hospital birth was a significant risk factor for early neonatal deaths (day 0 and days 1-6) but protective of late neonatal death. Clinic birth was protective of neonatal deaths throughout the neonatal period.

Hospital births

Among babies delivered in hospital, univariate analyses of the complete cases (Table 4.3.4) showed that teenage mothers and those aged 30-39 years had an increased risk of neonatal mortality compared to mothers aged 20-29 years. Poor mothers were twice as likely to lose their babies in the neonatal period compared to rich mothers. The risk of death decreased with increasing maternal education. Twins were approximately five times more likely than singletons to die. Although boys and first births appeared to be at a slightly higher risk of death, the associations were not statistically significant. The univariate analyses of the imputed data (Table 4.3.6) showed similar results. After adjusting for confounding variables, only the associations for twin births and first births remained statistically significant.

Clinic births

Among babies delivered in the clinic, univariate analyses of complete and imputed cases showed that mothers of four or more children were less likely to lose their babies in the neonatal period and twins were more likely to die in the neonatal period. Boys and first borns appeared to be at increased risk, but the associations were not statistically significant. After adjusting for confounding variables, only the association for twins remained statistically significant.

Home births

Univariate analyses of complete (Table 4.3.4) and imputed data (Table 4.3.6) showed that among babies delivered at home, unmarried women, first time mothers, twins, and those born on a weekend were at increased risk of neonatal mortality compared to married women, multiparous, singletons, and babies born on a weekday. In the multivariable analyses (Table 4.3.5 and Table 4.3.7) first time mothers and twin births remained at increased risk of neonatal mortality and the risk of neonatal mortality decreased with parity.

Table 4.3.4: Univariate logistic regression analyses of factors associated with neonatal mortality in Navrongo (complete case model)

	Hospital (N=7,306)		Clinic (N=2,708)		Home (N=7,002)		Overall (N=17,016)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of birth									
Hospital	-		-		-		1.03 (0.82-1.31)	0.77	
Clinic	-		-		-		0.57 (0.39-0.85)	<0.01	
Home	-		-		-		1.00		
Maternal age (years)									
<20	1.78 (1.11-2.87)	0.02	1.72 (0.65-4.50)	0.27	1.57 (0.96-2.57)	0.07	1.66 (1.20-2.29)	<0.01	0.07
20-29	1.00		1.00		1.00		1.00		
30-39	1.73 (1.21-2.49)	<0.01	1.24 (0.55-2.81)	0.60	0.78 (0.52-1.17)	0.23	1.21 (0.93-1.55)	0.15	
40+	0.90 (0.39-2.09)	0.81	0.39 (0.05-2.97)	0.36	0.75 (0.42-1.34)	0.33	0.80 (0.50-1.27)	0.34	
Socioeconomic status									
Poor	2.04 (1.19-3.53)	0.01	0.76 (0.19-3.07)	0.70	0.76 (0.29-1.96)	0.57	1.22 (0.82-1.81)	0.33	0.34
Next poor	0.78 (0.36-1.69)	0.52	1.34 (0.34-5.22)	0.67	1.03 (0.40-2.68)	0.95	1.24 (0.81-1.89)	0.32	
Average	1.31 (0.72-2.39)	0.38	1.72 (0.45-6.53)	0.43	0.49 (0.17-1.39)	0.18	1.02 (0.65-1.60)	0.92	
Next rich	1.62 (0.99-2.65)	0.06	0.63 (0.13-3.13)	0.57	0.63 (0.23-1.74)	0.37	1.18 (0.77-1.79)	0.45	
Rich	1.00		1.00		1.00		1.00		
Marital status									
Not married	1.06 (0.71-1.57)	0.79	1.64 (0.70-3.82)	0.26	1.73 (1.13-2.67)	0.01	1.34 (1.02-1.76)	0.04	
Married	1.00		1.00		1.00		1.00		
Education									
None	1.31 (0.87-1.96)	0.19	1.02 (0.47-2.22)	0.96	0.92 (0.65-1.31)	0.66	1.03 (0.80-1.32)	0.81	0.11
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.67 (0.44-1.02)	0.06	0.90 (0.26-3.07)	0.86	0.77 (0.31-1.92)	0.58	0.72 (0.51-1.03)	0.07	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.67 (0.43-1.07)	0.09	0.53 (0.19-1.47)	0.22	0.28 (0.16-0.50)	<0.001	0.48 (0.34-0.68)	<0.001	<0.01
3	0.87 (0.54-1.39)	0.56	0.81 (0.32-2.01)	0.65	0.41 (0.25-0.67)	<0.001	0.65 (0.47-0.90)	<0.01	
4+	1.03 (0.68-1.57)	0.89	0.34 (0.12-0.95)	0.04	0.42 (0.28-0.63)	<0.001	0.64 (0.48-0.84)	<0.01	
Sex									
Female	1.00		1.00		1.00		1.00		
Male	1.32 (0.95-1.83)	0.10	1.32 (0.65-2.71)	0.44	1.30 (0.93-1.82)	0.13	1.31 (1.05-1.64)	0.02	
Twins	4.82 (3.06-7.58)	<0.001	3.57 (1.06-11.99)	0.04	4.20 (2.49-7.11)	<0.001	4.51 (3.24-6.26)	<0.001	
Weekend	1.03 (0.72-1.47)	0.87	0.71 (0.29-1.74)	0.45	1.56 (1.11-2.21)	0.01	1.22 (0.97-1.55)	0.09	
Year of birth	0.98 (0.96-1.00)	0.01	0.95 (0.91-0.98)	0.01	0.98 (0.96-1.00)	0.09	0.98 (0.97-0.99)	<0.001	

Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity and day of birth

Table 4.3.5: Multivariable logistic regression analyses of factors associated with neonatal mortality in Navrongo (complete case model)

	Hospital (N=5,346)		Clinic (N=2,352)		Home (N=4,440)		Overall (N=12,138)		P for trend
	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	
Place of birth									
Hospital	-		-		-		1.08 (1.02-1.14)	0.01	
Clinic	-		-		-		0.67 (0.63-0.72)	<0.001	
Home	-		-		-		1.00		
Maternal age (years)									
<20	1.52 (0.79-2.90)	0.21	1.04 (0.32-3.46)	0.94	0.83 (0.40-1.72)	0.62	1.18 (0.75-1.83)	0.48	0.60
20-29	1.00		1.00		1.00		1.00		
30-39	1.70 (0.98-2.95)	0.06	2.17 (0.76-6.21)	0.15	1.02 (0.54-1.96)	0.94	1.46 (1.04-2.05)	0.03	
40+	0.54 (0.15-1.95)	0.35	1.17 (0.12-11.02)	0.89	0.66 (0.26-1.69)	0.39	0.72 (0.58-0.90)	<0.01	
Socioeconomic status									
Poor	1.83 (0.99-3.38)	0.05	0.91 (0.19-4.27)	0.90	1.42 (0.42-4.84)	0.58	1.47 (1.22-1.78)	<0.001	<0.001
Next poor	0.62 (0.26-1.47)	0.27	1.50 (0.33-6.76)	0.60	1.70 (0.50-5.79)	0.40	1.33 (0.72-2.44)	0.36	
Average	1.05 (0.53-2.07)	0.90	2.20 (0.51-9.46)	0.29	0.85 (0.23-3.17)	0.81	1.13 (0.77-1.68)	0.53	
Next rich	1.28 (0.73-2.24)	0.38	0.66 (0.12-3.67)	0.64	1.10 (0.31-3.96)	0.88	1.20 (1.03-1.39)	0.02	
Rich	1.00		1.00		1.00		1.00		
Marital status									
Not married	0.77 (0.44-1.34)	0.35	1.72 (0.67-4.42)	0.26	1.23 (0.68-2.20)	0.50	1.03 (0.69-1.53)	0.89	
Married	1.00		1.00		1.00		1.00		
Education									
None	1.23 (0.72-2.09)	0.44	0.89 (0.35-2.25)	0.81	1.19 (0.75-1.88)	0.47	1.13 (1.06-1.21)	<0.001	<0.001
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.74 (0.42-1.30)	0.29	0.74 (0.18-3.01)	0.68	0.94 (0.32-2.73)	0.91	0.76 (0.69-0.84)	<0.001	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.52 (0.27-0.99)	0.05	0.65 (0.20-2.11)	0.47	0.21 (0.09-0.49)	<0.001	0.41 (0.21-0.78)	0.01	0.05
3	0.66 (0.34-1.28)	0.21	0.82 (0.5-2.76)	0.75	0.32 (0.16-0.67)	<0.01	0.54 (0.32-0.92)	0.02	
4+	0.67 (0.32-1.39)	0.28	0.22 (0.05-1.02)	0.05	0.42 (0.20-0.88)	0.02	0.49 (0.31-0.77)	<0.01	
Boys	1.26 (0.84-1.88)	0.27	2.05 (0.91-4.64)	0.09	1.41 (0.92-2.17)	0.12	1.38 (1.18-1.61)	<0.001	
Twins	5.27 (3.04-9.13)	<0.001	5.29 (1.46-19.23)	0.01	4.17 (2.10-8.29)	<0.001	5.06 (4.40-5.82)	<0.001	
Weekend	1.01 (0.62-1.57)	0.96	0.52 (0.18-1.53)	0.24	1.27 (0.81-1.99)	0.29	1.05 (0.79-1.39)	0.75	
Year of birth	0.99 (0.96-1.01)	0.37	0.96 (0.91-1.01)	0.12	0.97 (0.94-1.01)	0.12	0.98 (0.97-0.99)	<0.01	

Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity and day of birth
Data for multivariable analyses is cover the years 2006-2012

Table 4.3.6: Univariate logistic regression analyses of factors associated with neonatal mortality in Navrongo (multiple imputations model)

	Hospital (N=7,306)		Clinic (N=2,708)		Home (N=7,002)		Overall (N=17,016)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of birth									
Hospital	-		-		-		1.03 (0.82-1.31)	0.77	
Clinic	-		-		-		0.57 (0.39-0.85)	0.01	
Home	-		-		-		1.00		
Maternal age (years)									
<20	1.78 (1.11-2.87)	0.02	1.72 (0.65-4.50)	0.27	1.57 (0.96-2.57)	0.07	1.66 (1.50-1.84)	<0.001	0.21
20-29	1.00		1.00		1.00		1.00		
30-39	1.73 (1.21-2.49)	<0.01	1.24 (0.55-2.81)	0.60	0.78 (0.52-1.17)	0.23	1.21 (0.67-2.18)	0.54	
40+	0.90 (0.39-2.09)	0.81	0.39 (0.05-2.97)	0.36	0.75 (0.42-1.34)	0.33	0.80 (0.68-0.93)	0.01	
Socioeconomic status									
Poor	1.80 (1.05-3.11)	0.03	0.90 (0.23-3.59)	0.89	0.87 (0.35-2.17)	0.77	1.23 (0.84-1.81)	0.29	0.21
Next poor	0.89 (0.41-1.93)	0.77	1.35 (0.35-5.31)	0.66	1.07 (0.43-2.65)	0.89	1.22 (0.83-1.81)	0.31	
Average	1.26 (0.71-2.25)	0.44	1.72 (0.45-6.49)	0.43	0.62 (0.23-1.65)	0.33	1.04 (0.70-1.57)	0.83	
Next rich	1.52 (0.94-2.45)	0.09	0.66 (0.13-3.30)	0.61	0.72 (0.27-1.92)	0.51	1.17 (0.73-1.89)	0.52	
Rich	1.00		1.00		1.00		1.00		
Marital status									
Not married	1.06 (0.71-1.57)	0.79	1.64 (0.70-3.82)	0.26	1.73 (1.13-2.67)	0.01	1.34 (0.95-1.89)	0.10	
Married	1.00		1.00		1.00		1.00		
Education									
None	1.29 (0.86-1.94)	0.21	1.03 (0.47-2.25)	0.94	0.92 (0.65-1.31)	0.65	1.03 (0.86-1.23)	0.77	0.16
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.67 (0.44-1.03)	0.07	0.89 (0.26-3.02)	0.84	0.78 (0.31-1.94)	0.59	0.73 (0.63-0.84)	<0.001	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.68 (0.43-1.07)	0.10	0.53 (0.19-1.47)	0.22	0.28 (0.16-0.50)	<0.001	0.48 (0.26-0.90)	0.02	0.16
3	0.88 (0.55-1.41)	0.60	0.81 (0.32-2.02)	0.65	0.41 (0.25-0.68)	<0.001	0.66 (0.38-1.12)	0.12	
4+	1.06 (0.69-1.60)	0.80	0.34 (0.12-0.96)	0.04	0.42 (0.29-0.63)	<0.001	0.65 (0.35-1.17)	0.15	
Boys	1.32 (0.95-1.83)	0.10	1.32 (0.65-2.71)	0.44	1.30 (0.93-1.82)	0.13	1.31 (1.29-1.33)	<0.001	
Twins	4.82 (3.06-7.58)	<0.001	3.57 (1.06-11.98)	0.04	4.21 (2.49-7.11)	<0.001	4.51 (4.00-5.08)	<0.001	
Weekend	1.03 (0.72-1.47)	0.87	0.71 (0.29-1.74)	0.45	1.56 (1.11-2.21)	0.01	1.22 (0.87-1.71)	0.24	
Year of birth	0.98 (0.96-1.00)	0.01	0.95 (0.0.91-0.98)	0.01	0.98 (0.96-1.00)	0.09	0.98 (0.97-0.99)	<0.001	

Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity and day of birth

Table 4.3.7: Multivariable logistic regression analyses of factors associated with neonatal mortality in Navrongo (multiple imputations model)

	Hospital (N=5,979)		Clinic (N=2,615)		Home (N=4,733)		Overall (N=13,327)		P for trend
	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	Multivariable OR (95% CI)	p-value	
Place of birth									
Hospital	-		-		-		1.14 (1.03-1.25)	0.01	
Clinic	-		-		-		0.67 (0.65-0.68)	<0.001	
Home	-		-		-		1.00		
Maternal age (years)									
<20	1.38 (0.75-2.53)	0.30	1.10 (0.33-3.63)	0.88	0.82 (0.40-1.70)	0.60	1.14 (0.78-1.65)	0.50	0.86
20-29	1.00		1.00		1.00		1.00		
30-39	1.65 (0.98-2.80)	0.06	2.25 (0.79-6.40)	0.13	0.98 (0.52-1.84)	0.94	1.42 (0.98-2.06)	0.06	
40+	0.68 (0.22-2.14)	0.51	1.27 (0.14-11.94)	0.83	0.64 (0.25-1.60)	0.34	0.76 (0.64-0.91)	<0.01	
Socioeconomic status									
Poor	1.74 (0.94-3.21)	0.08	0.90 (0.19-4.15)	0.89	0.88 (0.33-2.40)	0.81	1.36 (0.97-1.90)	0.07	<0.001
Next poor	0.71 (0.31-1.64)	0.43	1.50 (0.34-6.66)	0.59	1.04 (0.38-2.81)	0.94	1.25 (0.85-1.84)	0.27	
Average	1.12 (0.58-2.18)	0.73	2.17 (0.51-9.19)	0.29	0.53 (0.18-1.59)	0.26	1.09 (0.65-1.81)	0.75	
Next rich	1.31 (0.76-2.26)	0.33	0.67 (0.12-3.65)	0.64	0.69 (0.24-1.98)	0.49	1.14 (0.82-1.59)	0.42	
Rich	1.00		1.00		1.00		1.00		
Marital status									
Not married	0.95 (0.58-1.55)	0.83	1.74 (0.69-4.43)	0.24	1.38 (0.79-2.41)	0.26	1.17 (0.85-1.59)	0.33	
Married	1.00		1.00		1.00		1.00		
Education									
None	1.16 (0.69-1.95)	0.57	0.91 (0.36-2.29)	0.85	1.20 (0.76-1.89)	0.44	1.12 (1.03-1.21)	0.01	<0.001
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.78 (0.46-1.32)	0.36	0.70 (0.18-2.78)	0.61	0.90 (0.31-2.61)	0.85	0.76 (0.67-0.87)	<0.001	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.50 (0.27-0.93)	0.03	0.69 (0.21-2.23)	0.53	0.21 (0.09-0.50)	<0.001	0.41 (0.23-0.74)	<0.01	0.04
3	0.64 (0.34-1.21)	0.17	0.80 (0.24-2.66)	0.72	0.38 (0.19-0.77)	0.01	0.58 (0.39-0.85)	0.01	
4+	0.69 (0.34-1.40)	0.31	0.23 (0.05-1.06)	0.06	0.45 (0.21-0.94)	0.03	0.52 (0.34-0.81)	<0.01	
Boys	1.28 (0.87-1.88)	0.20	2.07 (0.92-4.69)	0.08	1.41 (0.92-2.16)	0.12	1.39 (1.20-1.60)	<0.001	

Twins	5.27 (3.14-8.85)	<0.001	5.08 (1.42-18.24)	0.01	4.91 (2.57-9.35)	<0.001	5.35 (5.16-5.55)	<0.001	
Weekend	0.95 (0.63-1.45)	0.82	0.52 (0.18-1.52)	0.23	1.35 (0.87-2.09)	0.18	1.05 (0.75-1.45)	0.79	
Year of birth	0.98 (0.96-1.00)	0.07	0.95 (0.90-1.01)	0.09	0.97 (0.94-1.00)	0.09	0.97 (0.97-0.98)	<0.001	
Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity and day of birth									
Data for multivariable analyses cover the years 2006-2012					m=50				

Table 4.3.8: Subgroup analyses of association between place of birth and neonatal mortality

	Hospital	P value	Clinic	P value	Home
	OR (95% CI)		OR (95% CI)		OR (95% CI)
Maternal age (years)					
<20	0.92 (0.85-1.00)	0.04	0.59 (0.50-0.70)	<0.001	1.00
20-29	0.95 (0.69-1.32)	0.77	0.65 (0.59-0.72)	<0.001	1.00
30-39	1.60 (1.42-1.78)	<0.001	0.74 (0.68-0.81)	<0.001	1.00
40+	1.17 (0.68-1.99)	0.57	0.52 (0.18-1.42)	0.20	1.00
Socioeconomic status					
Poor	1.38 (1.28-1.50)	<0.001	0.36 (0.27-0.46)	<0.001	1.00
Next poor	0.42 (0.35-0.50)	<0.001	0.64 (0.55-0.75)	<0.001	1.00
Average	1.92 (1.78-2.06)	<0.001	2.31 (1.75-3.05)	<0.001	1.00
Next rich	1.41 (1.25-1.58)	<0.001	0.45 (0.39-0.52)	<0.001	1.00
Rich	0.62 (0.41-0.95)	0.03	0.52 (0.30-0.91)	0.02	1.00
Education					
None	1.40 (1.20-1.64)	<0.001	0.63 (0.56-0.71)	<0.001	1.00
Basic	1.07 (0.94-1.22)	0.31	0.68 (0.63-0.72)	<0.001	1.00
Secondary+	0.95 (0.66-1.37)	0.79	0.91 (0.62-1.32)	0.61	1.00
Parity					
1	0.95 (0.72-1.24)	0.69	0.63 (0.53-0.76)	<0.001	1.00
2	1.48 (0.57-3.82)	0.42	1.66 (0.97-2.84)	0.07	1.00
3	1.14 (0.76-1.71)	0.53	0.90 (0.74-1.10)	0.31	1.00
4+	1.17 (0.79-1.72)	0.44	0.27 (0.19-0.40)	<0.001	1.00
Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity, day of birth and year of birth					
Data for multivariable analyses covers the years 2006-2012					

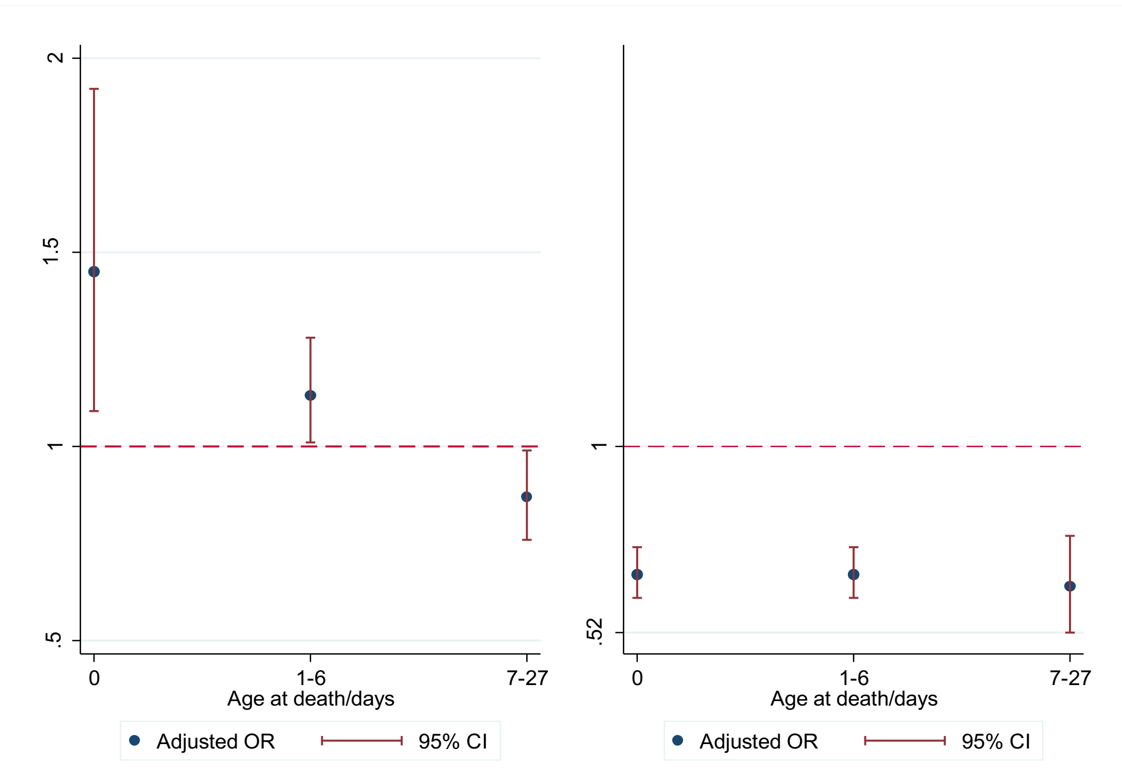


Fig 4.3.3: Forest plot of adjusted* odds ratio for the association between place of birth and neonatal mortality, according to age at death (Left- Hospital births, Right- Clinic births, Reference line- Home births)

Adjusted for place of delivery, year of birth, maternal age, socioeconomic status, marital status, education, sex, multiple birth, parity, day of birth and year of birth.

Fig 4.3.3 shows a forest plot of the association between place of birth and neonatal mortality, according to the baby's age at death. The graph shows that among hospital (left) and clinic (right) births, the risk of neonatal death decreases over the neonatal period. Compared to babies born at home (reference line), babies born in hospital are at a significant increased risk of death on the day of birth and days 1-6, but at a lower risk of death thereafter. Compared to home births (reference line), babies born in clinics remained at a lower risk of death throughout the neonatal period.

4.3.4 Neonatal deaths in Navrongo

This section summarises the characteristics of neonatal deaths in the Navrongo HDSS from 2004 to 2012, according to age at death, cause of death, place of birth and place of death.

4.3.4.1 Age at death

Overall, 320 babies died within 28 days of birth in the Navrongo HDSS during the study period. Of these 223 (69.7%) died over 0-6 days, representing an early NMR of 13.1, and 97 (30.3%) died over 7-27 days, representing a late NMR of 5.7. Of the early neonatal deaths, 90 (40%) died on the first day of birth. The distribution of neonatal deaths by the age at death is shown in the bar graph in Fig 4.3.4.

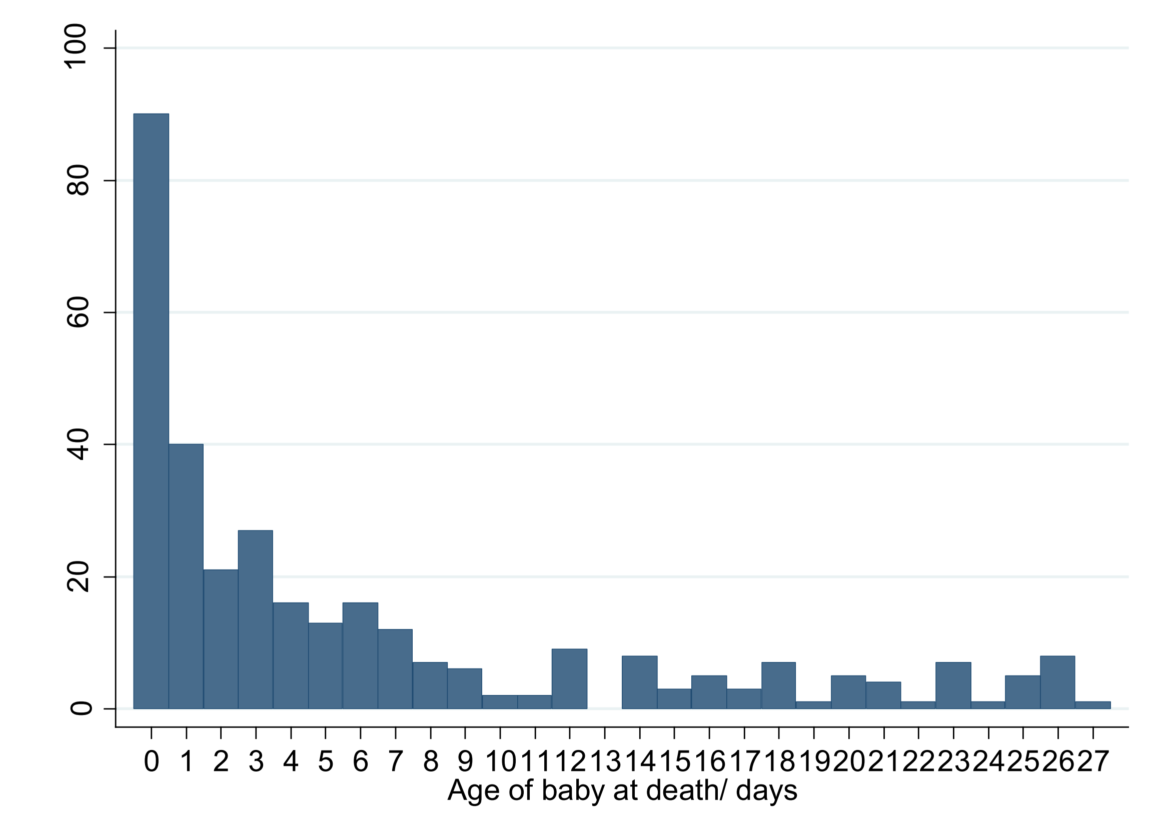


Fig 4.3.4: Distribution of neonatal deaths by age at death

Age of neonatal deaths by place of birth

Table 4.3.9 shows the distribution of neonatal deaths by place of birth and place of death, stratified by the age of baby at death. Of the 320 deaths, 160 deaths (61%) occurred at home, 89 (34%) in hospital, 8 (3%) in a clinic and 4 (2%) occurred in other places. One hundred and two (82.3%) neonatal deaths among babies born at home occurred at home (home/home); 40% of the deaths among babies born in hospital occurred at home (hospital/home); and 52% of neonatal deaths among clinic births occurred at home (clinic/home). Meanwhile only 14% of the deaths of babies born at home occurred in hospital (home/hosp), 30% of the deaths of babies born in a clinic occurred in hospital (clinic/hosp) and 57% of the deaths of babies born in hospital occurred in hospital (hosp/hosp). The difference in NMR by place of birth was statistically significant overall and for babies who died in the early neonatal period. The NMRs according to where a baby was born and where they died are as follows: Hosp/Hosp=8.9, Hosp/Home=6.3, Clinic/Clinic=1.5, Clinic/Home=4.4, Clinic/Hosp=2.6, Home/Home=14.6, Home/Hosp=2.4.

When babies who did not die at the same place as they were born were excluded from the sample (in order to determine the level of risk associated with hosp/hosp, clinic/clinic or home/home), a multivariable logistic regression analyses showed that hospital births were 25% less likely (adjusted OR 0.75, 95% CI 0.66-0.87, p<0.001) to die in a hospital and clinic births were 85% less likely (adjusted OR 0.15, 95% CI 0.13-0.17, p<0.001) to die in a clinic compared to home births.

Table 4.3.9: Characteristics of neonatal deaths by place of birth and place of death

	Place of birth				
Place of death	**Hospital**	**Clinic**	**Home**	**Total**	**p-value**
Overall (n=320)					
Hospital	65 (57.0)	7 (30.4)	17 (13.7)	89 (34.1)	<0.001
Clinic	1 (0.9)	4 (17.4)	3 (2.4)	8 (3.1)	
Home	46 (40.4)	12 (52.2)	102 (82.3)	160 (61.3)	
Other	2 (1.8)	0 (0.0)	2 (1.6)	4 (1.5)	
Missing	36	8	15	59	
Day 0 (n=90)					
Hospital	26 (78.9)	2 (40.0)	3 (8.6)	31 (42.5)	<0.001
Clinic	0	2 (40.0)	1 (2.9)	3 (4.1)	
Home	7 (21.2)	1 (20.0)	31 (88.6)	39 (53.4)	
Missing	9	2	6	17	
1-6 days (n=133)					
Hospital	28 (65.1)	3 (27.3)	7 (14.0)	38 (36.5)	<0.001
Clinic	2 (4.7)	1 (9.1)	2 (4.0)	5 (4.8)	
Home	13 (30.2)	7 (63.4)	40 (80.0)	60 (57.7)	
Other	0	0	1 (2.0)	1 (1.0)	
Missing	21	4	4	29	
7-27 days (n=97)					
Hospital	11 (29.0)	2 (28.6)	7 (18.0)	20 (23.8)	0.39
Clinic	1 (2.6)	1 (14.3)	1 (2.6)	3 (3.6)	
Home	26 (68.4)	4 (57.1)	31 (79.5)	61 (72.6)	
Missing	6	2	5	13	

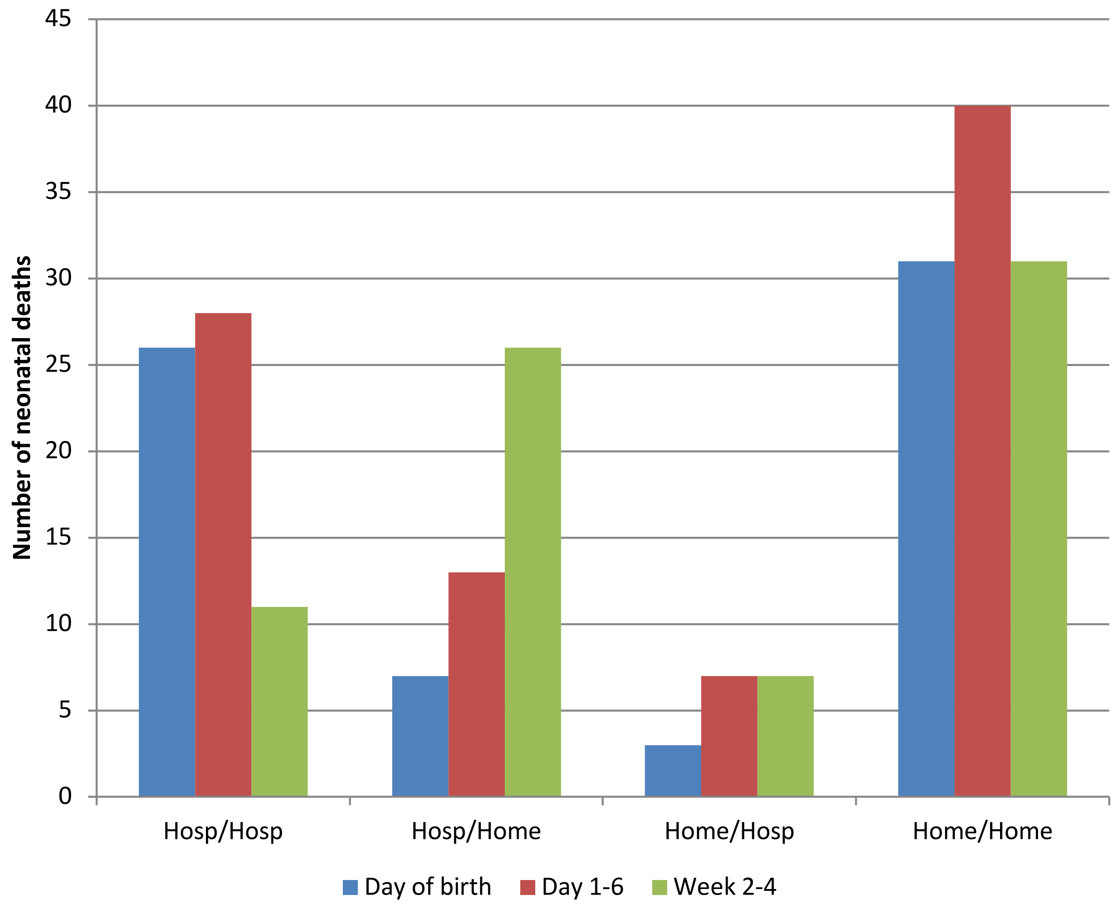


Fig 4.3.5: Number of newborn death by place of birth/place of death according to age at death

The bar graph in Fig 4.3.5 shows the age of neonatal deaths according to where they were born and where they died (born/died). The graph shows that overall more babies who were born at home also died at home (n=102, 82.3%) and fewer babies born at home died in hospital (n=17, 13.7%). Twenty-six (40%) of those born in hospital and also died in hospital (hosp/hosp), and 31 (30%) of babies born at home and also died at home (home/home) died on the day of birth. The majority (57%) of babies who were born in hospital but died at home died after the first week.

Age of neonate at death by place of birth, stratified by place of death

Table 4.3.10 summarises the age of neonatal deaths by place of delivery. The table shows no statistically significant difference between early and late neonatal deaths by place of birth, overall. However, when these deaths were broken down according to place of death, significant differences are observed among babies who died at home. Among home deaths, those who were born at home were more likely to die in the early neonatal period and those born in hospital were more likely to die in the late neonatal period.

Table 4.3.10: Age of neonate at death by place of birth (Navrongo)

	Place of birth				
Age at death	**Hospital (n=150)**	**Clinic (n=31)**	**Home (n=139)**	**Total**	**p-value**
	n (%)	**n (%)**	**n (%)**	**N (%)**	
All deaths (n=320)					
0	42 (28.0)	7 (22.6)	41 (29.5)	90 (28.1)	0.95
1-6	64 (42.7)	15 (48.4)	54 (38.8)	133 (41.6)	
7-27	44 (29.3)	9 (29.0)	44 (31.7)	97 (30.3)	
Hospital deaths only (n=89)					
0	26 (40.0)	2 (28.6)	3 (17.7)	31 (34.8)	0.07
1-6	28 (43.1)	3 (42.9)	7 (41.2)	38 (42.7)	
7-27	11 (16.9)	2 (28.6)	7 (41.2)	20 (22.5)	
Clinic deaths only (n=8)					
0	0	2 (50.0)	1 (33.3)	3 (37.5)	0.90
1-6	1 (100)	1 (25.0)	1 (33.3)	3 (37.5)	
7-27	0	1 (25.0)	1 (33.3)	2 (25.0)	
Home deaths only (n=160)					
0	7 (15.2)	1 (8.3)	31 (30.4)	39 (24.4)	0.01
1-6	13 (28.3)	7 (58.3)	40 (39.2)	60 (37.5)	
7-27	26 (56.5)	4 (33.3)	31 (30.4)	61 (38.1)	

5.3.4.2 Causes of neonatal deaths

The leading causes of neonatal death in Navrongo during the study period were infection (29%), asphyxia (23%) and prematurity (18%). The cause specific neonatal mortality rates (CSNMR) were as follows; infection (CSNMR=5.1), prematurity (CSNMR=3.2) and asphyxia (CSNMR=4.2). This section shows the distribution of the causes of neonatal deaths by age at death, place of birth and death and the temporal trends in CSNMR.

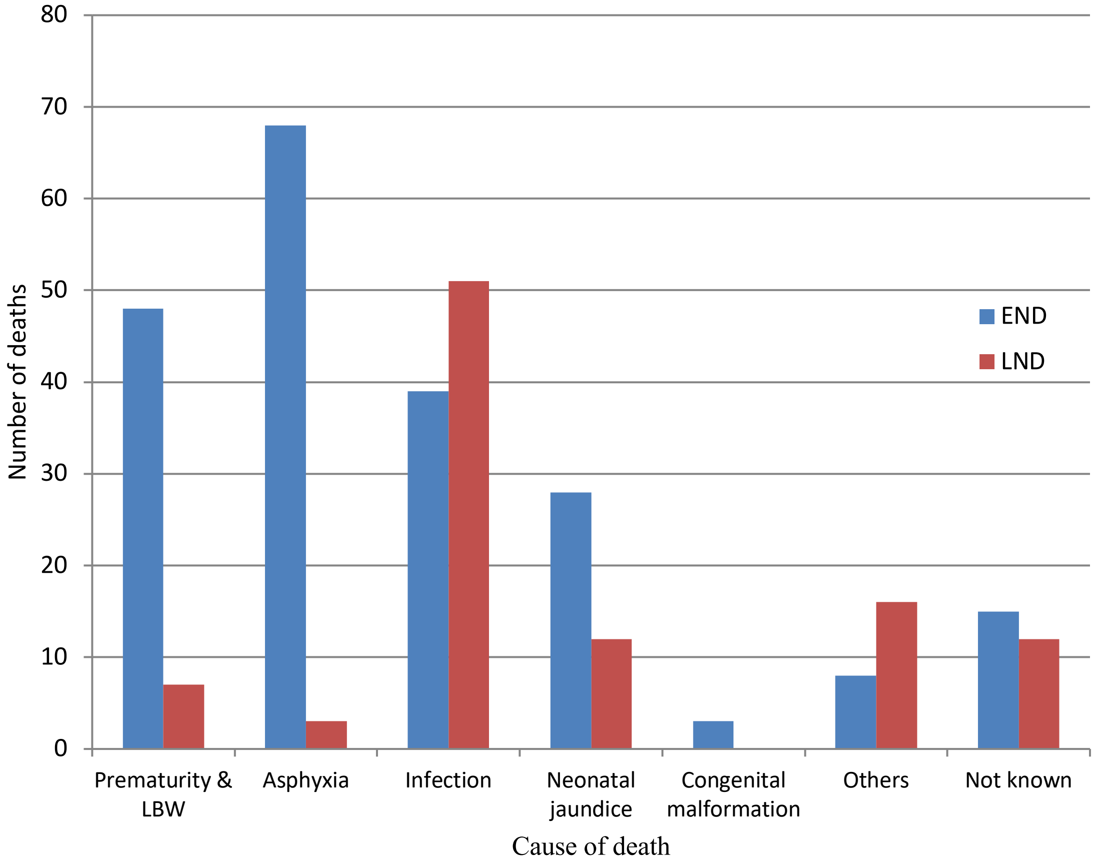


Fig 4.3.6: Causes of neonatal death by age at death

Fig 4.3.6 is a bar graph showing the distribution of neonatal deaths by the cause of death and age at death. The three most common causes of neonatal mortality in Navrongo were infection (29%), asphyxia (23%) and prematurity (18%). Prematurity and asphyxia were the leading causes of deaths over 0-6 days. Asphyxia was responsible for 47% of deaths which occurred on the day of birth and prematurity was responsible for 18% of these deaths. Infection was the leading cause of death over 7-27 days. The differences in cause of death by age at death were statistically significant ($p<0.001$)

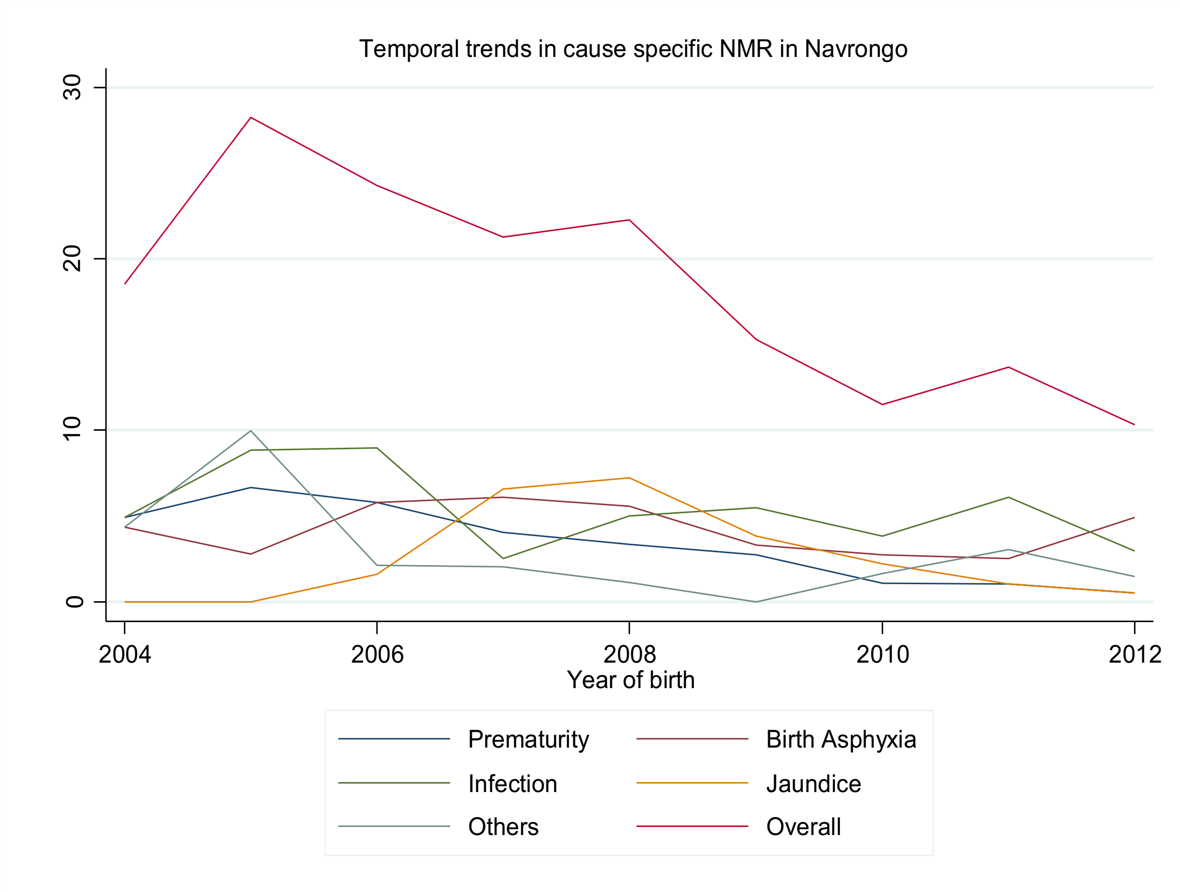


Fig 4.3.7: Temporal trends in cause specific neonatal mortality rate (CSNMR) in Navrongo

The line graph in Fig 4.3.7 shows the temporal trends in CSNMR in Navrongo. The graph shows that, overall, NMR in Navrongo has reduced over the study period. The prematurity CSNMR has decreased substantially over the study period (from 6.6 per 1,000 in 2005 to 0.5 in 2012) but the CSNMR trends for asphyxia appears to be increasing following an initial decline from 2007-2011. The CSNMR for the other diseases have not been consistent.

Cause of death by place of birth and death

Table 4.3.11 describes the causes of neonatal death by place of birth and death. Although there were no statistically significant differences in the causes of death by place of birth and place of death, it is shown that asphyxia was the commonest cause of death of babies born in hospital, whereas infection was the commonest cause death of babies born in clinic and at home.

Table 4.3.11: Cause of death by place of birth and age at death

	Place of birth				
Cause of death	**Hospital**	**Clinic**	**Home**	**Total**	**p-value**
Overall deaths (n=320)					
Prematurity & LBW	20 (14.1)	4 (14.3)	31 (23.3)	55 (18.2)	0.68
Asphyxia	42 (29.6)	8 (28.6)	21 (15.8)	71 (23.4)	
Infection	36 (25.4)	11 (39.3)	40 (30.1)	87 (28.7)	
Neonatal jaundice	15 (10.6)	2 (7.1)	23 (17.3)	40 (13.2)	
Congenital	1 (0.7)	1 (3.6)	1 (0.8)	3 (1.0)	
Assault and accident	3 (2.1)	2 (7.1)	2 (1.5)	7 (2.3)	
Others	8 (5.6)	0	5 (3.8)	13 (4.3)	
Not known	17 (12.0)	0	10 (7.5)	27 (8.9)	
Missing	8	3	6	16	
Died on day of birth (n=90)					
Prematurity & LBW	4 (9.8)	1 (14.3)	10 (27.0)	15 (17.6)	0.23
Asphyxia	22 (53.7)	6 (85.7)	12 (32.4)	40 (47.1)	
Infection	2 (4.9)	0	5 (13.5)	7 (8.2)	
Neonatal jaundice	6 (14.6)	0	8 (21.6)	14 (16.5)	
Others	3 (7.3)	0	0	10 (11.8)	
Not known	4 (9.8)	0	2 (5.4)	6 (7.1)	
Missing	1	0	4	5	
Days 1-6 (n=133)					
Prematurity & LBW	15 (25.4)	2 (16.7)	16 (30.2)	33 (26.6)	0.74
Asphyxia	18 (30.5)	2 (16.7)	8 (15.1)	28 (22.6)	
Infection	14 (23.7)	6 (50.0)	11 (20.8)	31 (25.0)	
Neonatal jaundice	9 (5.1)	1 (8.3)	10 (18.9)	14 (11.3)	
Congenital	1 (1.7)	1 (8.3)	1 (1.9)	3 (2.4)	
Assault and accident	0	0	1 (1.9)	1 (0.8)	
Others	2 (3.4)	0	3 (5.7)	5 (4.0)	
Not known	6 (10.2)	0	3 (5.7)	9 (7.3)	
Missing	5	3	1	9	
Days 7-27 (n=97)					
Prematurity & LBW	1 (2.4)	1 (11.1)	5 (11.6)	7 (7.5)	0.25
Asphyxia	2 (4.8)	0	1 (2.3)	3 (3.2)	
Infection	20 (47.6)	5 (55.6)	24 (55.8)	49 (52.1)	
Neonatal jaundice	6 (14.3)	1 (11.1)	5 (11.6)	12 (12.8)	
Assault and accident	3 (7.1)	2 (22.2)	1 (2.3)	6 (6.4)	
Others	3 (7.1)	0	2 (4.7)	5 (5.3)	
Not known	7 (16.7)	0	5 (11.6)	12 (12.8)	
Missing	2	0	1	3	
	Place of death				
	Hospital	**Clinic**	**Home**	**Total**	
Cause of death					
Prematurity & LBW	18 (20.2)	1 (12.5)	32 (20.1)	51 (19.9)	0.26
Asphyxia	32 (35.7)	3 (37.5)	24 (15.1)	59 (23.0)	
Infection	14 (15.7)	1 (12.5)	55 (34.6)	70 (27.3)	
Neonatal jaundice	10 (11.2)	2 (25.0)	27 (17.0)	39 (15.2)	
Congenital	2 (2.3)	0	0	2 (0.8)	
Assault and accident	0	0	5 (3.1)	5 (2.3)	
Others	2	1 (12.5)	1 (0.6)	4 (1.6)	
Not known	11 (12.4)	0	15 (9.4)	26 (10.2)	
Not known refers to undetermined after 3 coding or insufficient information					
Other refers to any unspecified cause of death					

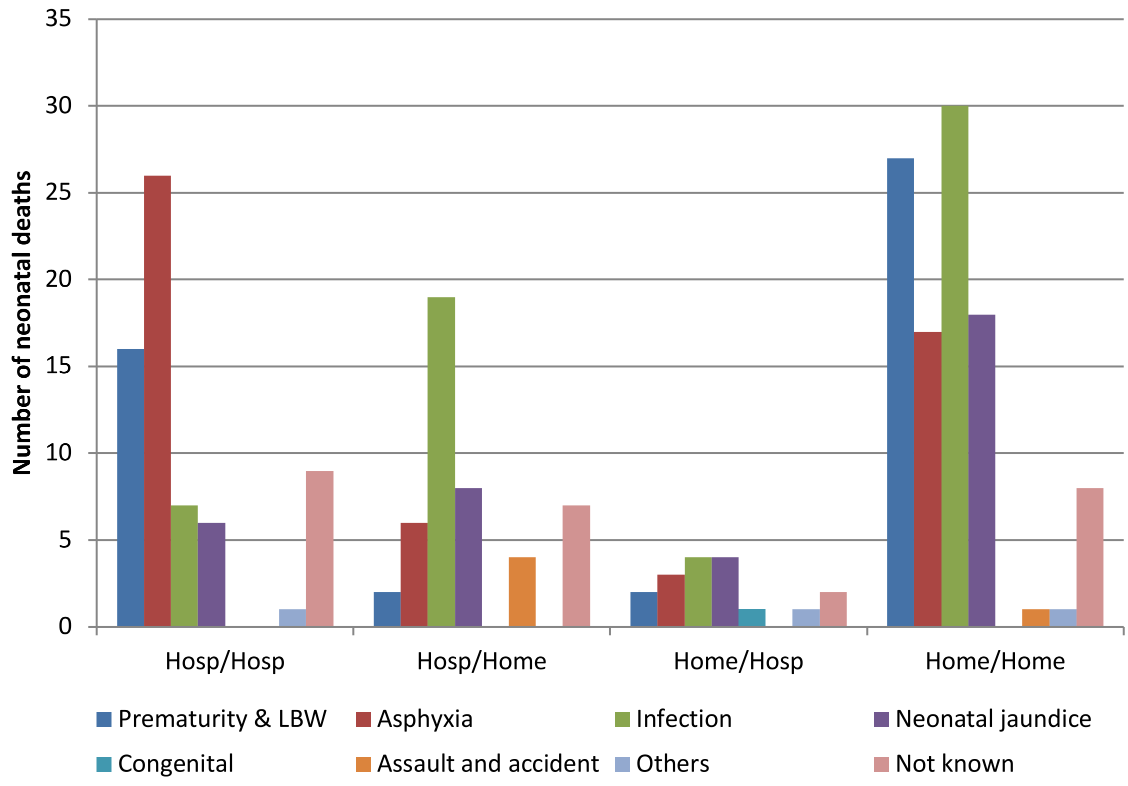


Fig 4.3.8: Number of neonatal deaths by place of birth/place of death according to cause of death

The bar graph in Fig 4.3.8 shows the causes of neonatal deaths according to where the baby was born and where s/he died (born/died). The graph shows that the leading causes of death by place of birth/place of death were: hospital/hospital (asphyxia-40%), hospital/home (infection-42%), home/hospital (neonatal jaundice and infection-24% each) and home/home (infection-29%). 50% of those who were born in clinic and died at home (clinic/home) died of infection.

Cause of death by significant risk factors

A profile (Table 4.3.12) of the neonatal deaths according to the factors which were found to be significantly associated with neonatal mortality in the multivariable analyses (education, parity, sex and twin) showed significant differences in the causes of death between multiple births and singletons. Multiple births were more likely to die of prematurity, asphyxia and jaundice. There was no statistical difference among multiple births by age at death and place of birth. There was also no statistical significant difference in cause of death among neonatal deaths by maternal age, parity, education or sex.

Table 4.3.12: Cause of death profile according to significant risk factors for neonatal mortality

	Prematurity	Asphyxia	Infection	Jaundice	Congenital	Assault	Others	Not known	Total*	p-value
Maternal education										
None	15 (16.0)	20 (21.3)	32 (34.0)	12 (12.8)	2 (2.1)	1 (1.1)	3 (3.2)	9 (9.6)	94	0.68
Basic	31 (18.7)	43 (25.9)	45 (27.1)	17 (10.2)	1 (0.6)	6 (3.6)	8 (4.8)	15 (9.0)	166	
Secondary+	7 (19.4)	6 (16.7)	9 (25.0)	9 (25.0)	0	0	2 (5.6)	3 (8.3)	36	
Maternal age										
<20 years	9 (18.0)	12 (24.0)	14 (28.0)	5 (10.0)	0	2 (4.0)	1 (2.0)	7 (14.0)	50	0.60
20-29	24 (17.9)	30 (22.4)	35 (26.1)	20 (14.9)	2 (1.5)	4 (3.0)	10 (7.5)	9 (6.7)	134	
30-39	16 (16.0)	26 (26.0)	31 (31.0)	14 (14.0)	1 (1.0)	1 (1.0)	1 (1.0)	10 (10.0)	100	
40+	6 (31.6)	3 (15.8)	7 (36.8)	1 (5.3)	0	0	1 (5.3)	1 (5.3)	19	
Multiple birth										
Singleton	43 (16.5)	59 (22.7)	79 (30.4)	31 (11.9)	3 (1.2)	7 (2.7)	13 (5.0)	25 (9.6)	260	0.04
Multiple	12 (27.9)	12 (27.9)	8 (18.6)	9 (20.9)	0	0	0	2 (4.7)	43	
First birth										
Yes	30 (24.6)	26 (21.31)	25 (20.5)	16 (13.1)	1 (0.8)	5 (4.1)	6 (4.9)	13 (10.7)	122	0.06
No	25 (14.0)	44 (24.6)	62 (34.6)	24 (13.4)	2 (1.1)	2 (1.1)	7 (3.9)	13 (7.3)	179	
Sex										
Female	25 (18.9)	29 (22.0)	40 (30.3)	19 (14.4)	1 (0.8)	3 (2.3)	6 (4.6)	9 (6.8)	132	0.97
Male	30 (17.5)	42 (24.6)	47 (27.5)	21 (12.3)	2 (1.2)	4 (2.3)	7 (4.1)	18 (10.5)	171	

4.3.5 Summary of key findings

This thesis found the NMR in the Navrongo HDSS from 2004-2012 was 18.8 and the rate reduced by 31% over the study period. Overall, babies born in hospital (NMR=20.5) had the highest NMR and clinic births (NMR=11.4) had the lowest. However when the data were stratified according to where the baby was born and where s/he died, babies born at home and died at home (home/home) had the highest NMR (14.6), compared to those born in hospital and died at hospital (8.9) and those who were born in clinic and died in clinic (clinic/clinic=1.5).

Overall, the risk of neonatal mortality decreased with increasing maternal education and parity. Twins had over five times increased risk of death compared to singletons and boys had 40% increased risk of death compared to girls. Overall, babies born in hospital were at a higher risk of death, compared to home births, and babies born in clinic had a lower risk of death. Subgroup analyses according to the baby's age at death showed that hospital births had a significantly increased risk of death for early neonatal deaths only, but a significantly lower risk for late neonatal deaths, and clinic births had significantly lower risk for neonatal mortality throughout the neonatal period. Subgroup analyses by maternal demographics showed that the overall lower risk of death among clinic births was not significant for older mothers, mothers with at least secondary education and those with 2 or 3 children. The overall increased risk of death among hospital births was significant for only older mothers, those with poor or average socioeconomic status and those with no education. Rich, next poor and teenage mothers were at a lower risk of neonatal mortality in hospital than home.

Over two-thirds of neonatal deaths occurred in the first week and the majority of these deaths occurred at home. The leading causes of neonatal deaths were prematurity (18%), asphyxia (23%) and infection (29%). Asphyxia and prematurity were the leading causes of early neonatal deaths and infection was the leading cause of late neonatal deaths. Asphyxia was the leading cause of death among hospital births and infection was the leading cause of death among clinic and home births. There was a higher proportion of babies born in hospital but died at home (hospital/home- 40%) compared to those born at home but died at hospital (home/hospital- 14%). Of the hospital/home deaths, 15% occurred on the day of birth and the majority (57%) died in the late neonatal period.

4.4 The Kintampo health and demographic surveillance system

This section describes the methods and results of the Kintampo HDSS. References to relevant sections in the Navrongo HDSS (section 4.3) have been made where similar procedures were employed.

4.4.1 Kintampo HDSS data management

Data extracts from the Kintampo HDSS covering the years 2005-2010 were received as two separate Microsoft excel files (.xlsx). These were electronic extracts of the birth registration form (n=11,257), which contained data on babies delivered in the Kintampo HDSS and their mothers, and the neonatal VA form (n=141), which contained additional information on babies who died within 28 days of birth. These two data files were imported into a Stata (.dta) compatible format and merged, using the unique neonatal identification number contained in both files, to create a single 'Kintampo HDSS dataset' (n=11,257). The baby's place of delivery was re-categorised into hospital, clinic or home by combining all the clinic options collected by Kintampo: health centres, CHPS, clinics and private maternity homes. The definitions of the various variables have been described previously in 4.2.4. Babies who were delivered on the way to hospital/clinic (n=22) and babies who were delivered in 'other' facilities (n=28), were excluded from the sample. The final sample thus contained 11,207 observations. The distribution of the characteristics of babies and mothers and the numbers of missing values has been summarised in Tables 4.4.1 and 4.4.2. The criteria for categorising variables and their definitions have been given previously in section 4.2.4

4.4.2 Statistical analyses

Statistical methods used for the descriptive and analytical statistics have been described previously in 4.2.5 and 4.3.2. Given the large number of missing values for ANC attendance and some other variables in the original Kintampo dataset, Stata's multiple imputations by chained equation (ICE) techniques were used to simulate plausible values for each missing datum. Forty additional datasets (m=40), each containing the simulated values for the missing data, were created based on the variable (ANC) with the highest fraction of missing information (FMI=0.403). Binary missing data were imputed using logit functions, categorical missing data were imputed using multinomial logit (mlogit) functions, and ordinal missing data were imputed using ordered logit (ologit) functions.

Univariate and multivariable binary logistic regression models were used to explore associations between the explanatory variables and neonatal mortality (dead/alive) for both complete and imputed cases. The multivariable logistic regression models (Tables 4.4.5 and 4.4.7) included the following explanatory variables: maternal age, socioeconomic status, sex, ANC attendance, multiple birth, parity, year of birth and day of birth. First birth was excluded from the multivariable models because it was found to be strongly correlated with parity and the univariate logistic regression also showed that first birth was not significantly associated with neonatal mortality. Regression models were run on the overall dataset to explore overall associations and stratified by place of birth to explore the risks for neonatal mortality according to where the baby was born.

4.4.3 Results

Overall, 11,257 babies were delivered in the Kintampo HDSS from 2005 to 2010. After excluding babies who were delivered on the way to hospital or clinic (n=22) and those delivered in 'other' facilities (n=28), the final sample contained 11,207 babies. Of these 11,207 babies, 3,634 (32.4%) were delivered in hospitals, 1,790 (16.0%) in clinics, and around half (n=5,783, 51.6%) at home. Most (n=11,067, 98.8%) of the babies delivered in Kintampo lived beyond 28 days of birth and 140 (1.2%) died within 28 days, giving an overall NMR of 12.5.

4.4.3.1 Summary characteristics of mothers and babies in Kintampo by place of delivery

Table 4.4.1 summarises the characteristics of mothers and babies in the Kintampo HDSS by place of birth. Of the mothers, 83.7% were aged 20-39 years old with a fairly even spread across the socioeconomic spectrum. Of the babies, 96.2% were singletons and 22.7% were firstborn.

The table shows statistically significant differences in maternal, birth and neonatal characteristics by place of delivery. Babies delivered in hospital were more likely than babies delivered in clinics or at home to die within 28 days of birth. The proportion of mothers who were delivered in hospitals increased with increasing socioeconomic status while home deliveries increased with decreasing socioeconomic status. The proportion of teenage and rich mothers was higher in hospital and that of older and poor mothers was higher at home. The table also shows that women with multiple pregnancies were more likely to deliver in hospital. Mothers were more likely to deliver their first baby in hospital; those having their second or third child were more likely to deliver in a clinic and those having their fourth or more child were more likely to deliver at home. The sex of the baby and day of birth did were unrelated to place of birth.

4.4.3.2 Neonatal mortality and neonatal mortality rates in Kintampo

The overall NMR in Kintampo over 2005-2010 was 12.5. This comprised a NMR of 18 among hospital births and 10 among both clinic and home births. The NMR increased with increasing maternal age and parity, and teenage mothers and mothers of one child had the lowest NMR of 8 each. Overall, twin deliveries had the highest neonatal mortality rate of 30.7 compared with 11.8 for singletons. Table 4.4.2 shows that babies delivered in hospital, those delivered by mothers over 30 years old, those with three or more children and twins were statistically significantly more likely to die in the neonatal period. Neonatal mortality did not differ significantly by the socioeconomic status of mother, sex of baby and day of birth.

Table 4.4.1: Summary of maternal and neonatal characteristics by place of delivery

	Hospital (n=3,634) n (%)	Clinic (n=1,790) n (%)	Home (n=5,783) n (%)	Total (n=11,207) n (%)	p-value
Mortality					
Alive	3,570 (98.2)	1,772 (99.0)	5,725 (99.0)	11067 (98.8)	0.003
Dead	64 (1.8)	18 (1.0)	58 (1.0)	140 (1.2)	
Maternal age (years)					
<20	328 (9.1)	158 (8.9)	477 (8.3)	963 (8.6)	<0.001
20-29	1,754 (48.4)	937 (53.0)	2,653 (45.9)	5,344 (47.9)	
30-39	1,294 (35.7)	586 (33.2)	2,114 (36.6)	3,994 (35.8)	
40+	246 (6.8)	86 (4.9)	531 (9.2)	863 (7.7)	
Missing	12	23	8	43	
Socioeconomic status					
Poor	472 (13.0)	205 (11.6)	1,134 (19.6)	1,811 (16.2)	<0.001
Next poor	606 (16.7)	350 (19.8)	1,182 (20.4)	2,138 (19.1)	
Average	683 (18.9)	356 (20.1)	1,272 (22.0)	2,311 (20.7)	
Next rich	844 (23.3)	407 (23.0)	1,258 (21.8)	2,509 (22.5)	
Rich	1,019 (28.1)	450 (25.5)	937 (16.2)	2,406 (21.5)	
Missing	10	22	0	32	
Sex					
Female	1,730 (47.6)	856 (47.8)	2,889 (50.0)	5,475 (48.9)	0.05
Male	1,904 (52.4)	934 (52.2)	2,894 (50.0)	5,732 (51.2)	
ANC					
Yes	2,818 (92.3)	1,407 (92.0)	3,917 (81.6)	8,142 (86.8)	<0.001
No	236 (7.7)	123 (8.0)	882 (18.4)	1,241 (13.2)	
Missing	580	260	984	1,824	
Twins					
No	3,380 (94.4)	1,712 (97.5)	5,566 (96.9)	10,658 (96.2)	<0.001
Yes	201 (5.6)	44 (2.5)	178 (3.1)	423 (3.8)	
Missing	53	34	39	126	
First birth					
Yes	1,103 (30.1)	469 (26.4)	969 (16.8)	2,541 (22.7)	<0.001
No	2,531 (69.7)	1,306 (73.6)	4,814 (83.2)	8,651 (77.3)	
Missing	0	15	0	15	
Parity					
1	1,041 (29.5)	444 (25.7)	911 (16.0)	2,396 (21.9)	<0.001
2	682 (19.3)	339 (19.6)	851 (14.9)	1,872 (17.1)	
3	528 (14.9)	319 (18.5)	874 (15.3)	1,721 (15.7)	
4+	1,282 (36.3)	625 (36.2)	3,068 (53.8)	4,975 (45.4)	
Missing	101	63	79	243	
Day of birth					
Weekday	2,588 (71.2)	1,308 (73.1)	4,119 (71.2)	8,015 (71.5)	0.28
Weekend	1,046 (28.8)	482 (26.9)	1,664 (28.8)	3,192 (28.5)	

Table 4.4.2: Summary of maternal and neonatal characteristics by neonatal mortality

	Total livebirths n (%)	Dead n (%)	NMR	P-value
Kintampo- All	11207	140	12.5	-
Place of birth				
Hospital	3,634 (32.4)	64 (45.7)	17.6	0.003
Clinic	1,790 (16.0)	18 (12.9)	10.1	
Home	5,783 (51.6)	58 (41.4)	10.0	
Maternal age (years)				
<20 years	963 (8.6)	8 (5.8)	8.3	<0.001
20-29	5,344 (47.9)	55 (39.6)	10.3	
30-39	3,994 (35.8)	54 (38.9)	13.5	
40+	863 (7.7)	22 (15.8)	25.5	
Missing	43	1		
Socioeconomic status				
Poor	1,811 (16.2)	24 (17.3)	13.3	0.40
Next poor	2,138 (19.1)	22 (15.8)	10.3	
Average	2,311 (20.7)	24 (17.3)	10.4	
Next rich	2,509 (22.5)	35 (25.2)	13.9	
Rich	2,406 (21.5)	34 (24.5)	14.1	
Missing	32	1		
Sex				
Female	5,475 (48.9)	61 (43.6)	11.1	0.21
Male	5,732 (51.2)	79 (56.4)	13.8	
ANC				
Yes	8,142 (86.8)	103 (82.4)	12.7	0.15
No	1,241 (13.2)	22 (17.6)	17.7	
Missing	1,824	15		
Twins				
No	10,658 (96.2)	126 (90.7)	11.8	0.001
Yes	423 (3.8)	13 (9.4)	30.7	
Missing	126	1		
First birth				
Yes	2,541 (22.7)	23 (16.4)	9.1	0.07
No	8,651 (77.3)	117 (83.6)	13.5	
Missing	15	0		
Parity				
1	2,396 (21.9)	19 (14.4)	7.9	0.02
2	1,872 (17.1)	19 (14.4)	10.1	
3	1,721 (15.7)	25 (18.9)	14.5	
4+	4,975 (45.4)	69 (52.3)	13.9	
Missing	243	8		
Day of birth				
Weekday	8,015 (71.5)	96 (68.6)	12.0	0.44
Weekend	3,192 (28.5)	44 (31.4)	13.8	

4.4.3.3 Temporal trends in neonatal mortality rate in Kintampo

This section describes the temporal trends in NMR in the Kintampo HDSS, the 3-year moving average NMR and NMR from 2005 to 2010, overall and by place of delivery.

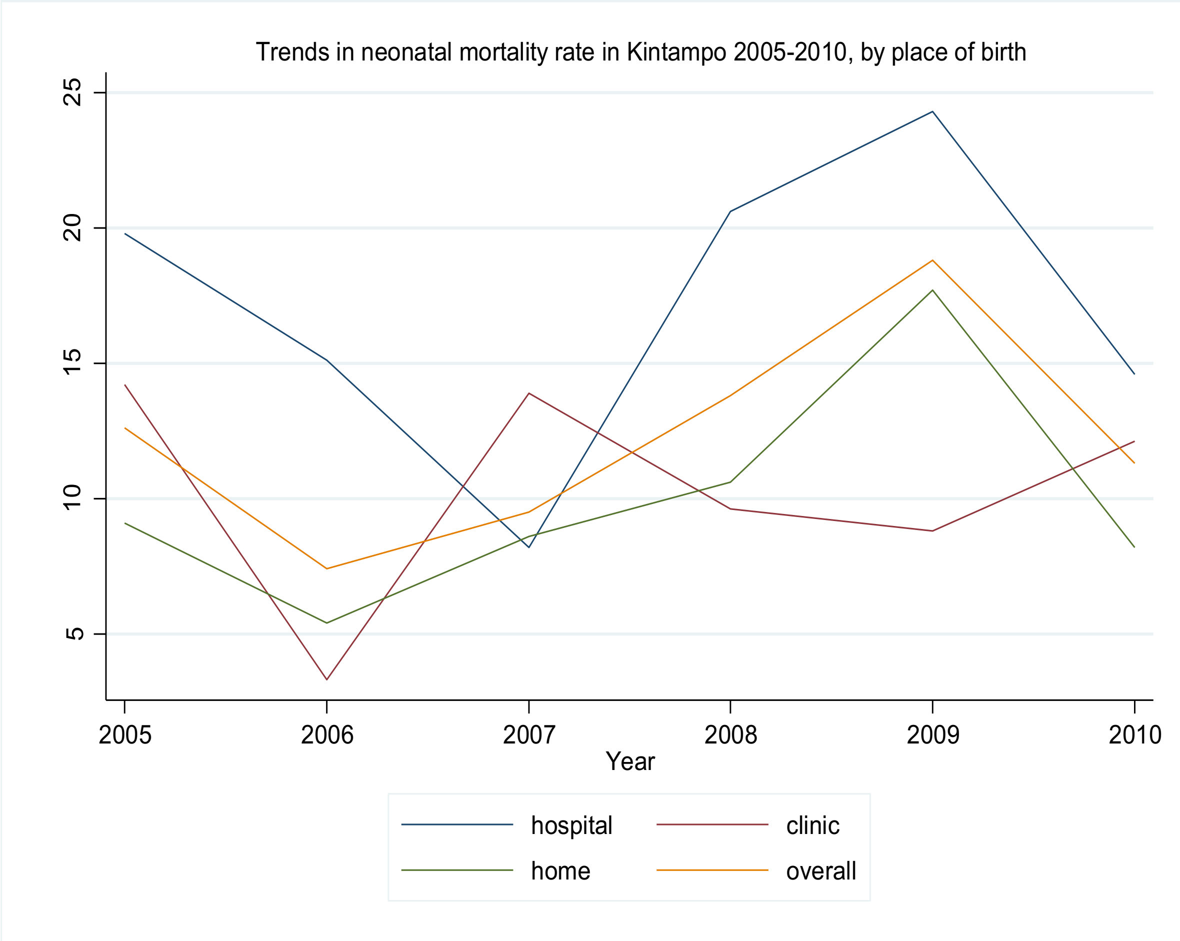


Fig 4.4.1: Temporal trends in neonatal mortality rate in Kintampo 2005-2010

Figure 4.4.1 depicts the temporal trends in NMR in the Kintampo HDSS from 2005 to 2010, overall and by place of delivery. The line graph shows three stages in the overall NMR in Kintampo: a decline from 12.6 to 7.4 between 2005 and 2006, a rise to 18.8 between 2006 and 2009 and a subsequent decline to 11.3 in 2010. The pattern was broadly similar by the place of delivery, and with exception of 2007, the NMR in hospital remained higher than clinics and home throughout the study period.

Table 4.4.3 provides the numerical data used to produce Figure 4.4.1. In addition, the table shows that the trends in NMR were not statistically significant, either overall or by place of delivery.

Table 4.4.3: Breakdown by year of birth and temporal trends in neonatal mortality rate in Kintampo

Year	Total livebirths	Dead n (%)	NMR	P for trend
Overall				
2005	1,266	16	12.6	0.12
2006	1,622	12	7.4	
2007	1,899	18	9.5	
2008	2,033	28	13.8	
2009	2,183	41	18.8	
2010	2,204	25	11.3	
Hospital				
2005	353	7	19.8	0.74
2006	397	6	15.1	
2007	489	4	8.2	
2008	679	14	20.6	
2009	824	20	24.3	
2010	892	13	14.6	
Clinic				
2005	141	2	14.2	0.74
2006	305	1	3.3	
2007	361	5	13.9	
2008	312	3	9.6	
2009	340	3	8.8	
2010	331	4	12.1	
Home				
2005	772	7	9.1	0.19
2006	920	5	5.4	
2007	1,049	9	8.6	
2008	1,042	11	10.6	
2009	1,019	18	17.7	
2010	981	8	8.2	

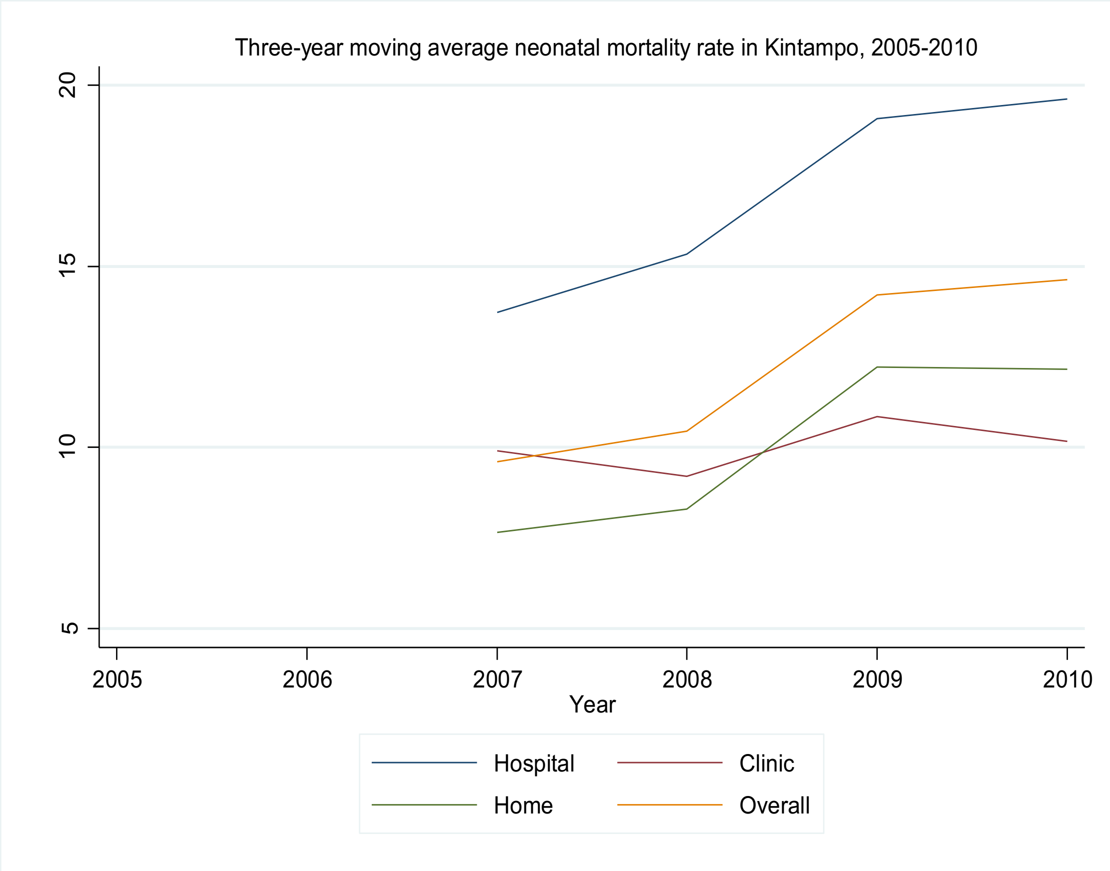


Fig 4.4.2: Three-year moving average of neonatal mortality rate in Kintampo

Figure 4.4.2 shows the three-year simple moving average NMR in Kintampo from 2005 to 2010. This allows observation of longer-term trends in NMR, by smoothing year-on-year volatility. The line graph shows that the overall moving average NMR in Kintampo increased over the study period. Hospital births consistently had higher average NMRs than both clinic and home births throughout the five-year period. Home births had the lowest moving average NMRs before 2009, and after 2009 clinic births had the lowest NMRs.

4.3.3.4 Factors associated with neonatal mortality in Kintampo

This section presents the results of univariate and multivariable binary logistic regression analyses of complete (Tables 4.4.4-4.4.5) and imputed datasets (Tables 4.4.6-4.4.7) for the associations between maternal, delivery and neonatal characteristics and neonatal mortality in Kintampo, overall and by place of delivery.

All births

Univariate logistic regression analyses of the complete cases (Table 4.4.4) showed that overall, place of delivery, maternal age, multiple birth and parity were significantly associated with neonatal mortality in Kintampo. Babies born in hospital (OR 1.77, 95% CI 1.24-2.53, p<0.001) were more likely than those born at home to die in the neonatal period but there was no statistical difference in the risk of neonatal mortality between babies born at home and those born in a clinic (OR 1.00, 95% CI 0.59-1.71, p=0.99). Babies of mothers aged over 40 were 2.5 times more likely to die than those of mothers aged 20-29. Babies that were their mother's third or subsequent child were 1.8 times more likely than those with one child, and twins were 2.6 times more likely than singletons to die in the neonatal period. Univariate analyses also showed significant trends in neonatal mortality by maternal age and parity. The unadjusted odds ratios for the imputed data (Table 4.4.6) showed similar results to the complete cases, except for parity which was not significant.

After adjusting for potentially confounding variables, babies born in hospital (adjusted OR 1.72, 95% CI 1.57-1.88, p<0.001) and those born in a clinic (adjusted OR 1.27, 95% CI 1.24-1.31, p<0.001) had a significantly increased risk of dying compared to babies born at home. In the multivariable analyses of the imputed data (Table 4.4.7), babies born in hospital were 76% more likely and those born in clinic were 12% more likely than those born at home to die within the neonatal period.

In the multivariable analyses of the complete cases, babies born to older mothers (>40 years), and those being their mother's third or subsequent child had a statistically significant increased risk of dying. The multivariable analyses of the imputed data showed older mothers (30 years or more), and twins were at a significantly higher risk of dying. Babies of multiparous mothers appeared to have an increased risk of dying but the association was not statistically significant.

Receiving ANC, which was not a statistically significant variable in either of the univariate models (Table 4.4.4 and 4.4.6), was found to be significantly associated with a lower risk of dying in the multivariable models, for both complete cases and the imputed datasets. This suggests that the univariate results for ANC were heavily confounded by the other explanatory variables. In the complete case analyses, babies born to mothers who attended ANC were 35% (adjusted OR 0.65, 95% CI 0.50-0.84, $p<0.001$) less likely than those who did not attend ANC to die in the neonatal period. Analyses of the imputed dataset showed similar results (adjusted OR 0.66, 95% CI 0.49-0.90, $p=0.01$).

The area under the ROC curve for the logistic regression model for complete cases was 68% (63%-73%) showing a moderate strength of the model. The adjusted population attributable fraction of overall neonatal deaths due to non-attendance at ANC in the complete cases was 7% (95% CI 3%-10%). A Hosmer-Lameshow test to check the goodness of fit produced non-significant results at varying degrees of freedom, indicative of a good fit.

To examine the risk factors for early and late neonatal deaths, the results for the overall associations between place of delivery and neonatal mortality were stratified according to the baby's age at death; days 0, 1-6 and 7-27 (Fig 4.3.4). The results showed that hospital birth was a significant risk factor for early neonatal deaths- day 0 deaths (adjusted OR 3.05, 95% CI 2.72-3.41, $p=0.01$) and days 1-6 deaths (adjusted OR 1.37, 95% CI 1.13-1.68, $p<0.01$), but not late neonatal deaths. Compared to home births, clinic births were less likely to die on the day of birth (adjusted OR 0.62, 95% CI 0.54-0.71, $p<0.001$) but were significantly more likely to die between days 1-6 (adjusted OR 1.47, 95% CI 1.29-1.67, $p<0.001$).

Hospital births

Among babies delivered in hospitals, univariate logistic regression of the complete cases found that those being their mother's fourth or subsequent child had a higher risk of dying, but univariate analyses of the imputed dataset (Table 4.4.4 & 4.4.6) did not find any of the recorded exposure variables to be associated with the risk of dying. After adjusting for potentially confounding variables, the multivariable logistic regression analyses of the complete cases showed that babies born in 2007 (adjusted OR 0.23, 95% CI 0.06-0.82, $p=0.03$) and 2010 (adjusted OR 0.34, 95% CI 0.12-0.97, $p=0.04$) had a significantly lower risk of death compared to babies born in 2005. Multivariable analyses of the imputed data did not show any significant association between any of the recorded exposure variables and the risk of dying among hospital births.

Clinic births

Among babies delivered in clinics, univariate analyses of complete and imputed cases showed that twins were five times more likely than singletons to die in the neonatal period, and the association was significant. After adjusting for maternal age, socioeconomic status, sex of the baby, ANC attendance, parity, year of birth and day of birth, the multivariable analyses of complete cases showed that the magnitude of the high risk of neonatal death among twins increased slightly (adjusted OR 6.16, 95% CI 1.18-32.27) but the association for the imputed dataset was not significant.

Home births

Among babies delivered at home, univariate analyses of both complete (Table 4.4.4) and imputed datasets (Table 4.4.6) showed that boys, twins and babies delivered to mothers over 40 years had a higher risk of death, compared to girls, singletons and mothers aged 20-29 years respectively. After adjusting for the recorded confounding variables in the complete dataset (Table 4.4.5), the adjusted odds ratio for neonatal mortality remained statistically significant for older mothers (adjusted OR 4.55, 95% CI 1.82-11.37, p=0.001) and twin births (adjusted OR 4.07, 95% CI 1.54-10.76, p=0.01) but not for the sex of the baby. In the multivariable analyses of the imputed dataset, the adjusted odds ratio for mothers over 40 years (adjusted OR 3.89, 95% CI 1.67-9.06, $p<0.01$), twin births (adjusted OR 4.07, 95% CI 1.67-9.90, $p<0.01$) and boys (adjusted OR 1.93, 95% CI 1.11-3.34, p=0.02) all remained statistically significant. Among babies delivered at home, the adjusted population attributable fraction of neonatal deaths due to twin births in the complete dataset was 7% (95% CI 2%-16%) and in the imputed dataset it was 8% (95% CI 6%-9%).

Table 4.4.4: Univariate logistic regression of factors associated with neonatal mortality in Kintampo (complete case analyses)

	Hospital (n=2,953)		Clinic (n=1,477)		Home (n=4,732)		Overall (N=9,162)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of delivery									
Hospital	-		-		-		1.77 (1.24-2.53)	<0.001	
Clinic	-		-		-		1.00 (0.59-1.71)	0.99	
Home	-		-		-		1.00		
Maternal age (years)									
<20	0.61 (0.18-2.04)	0.43	0.66 (0.08-5.22)	0.69	1.11 (0.38-3.27)	0.85	0.81 (0.38-1.70)	0.57	0.001
20-29	1.00		1.00		1.00		1.00		
30-39	1.36 (0.79-2.36)	0.27	1.25 (0.46-3.37)	0.66	1.32 (0.71-2.44)	0.38	1.32 (0.90-1.92)	0.15	
40+	2.23 (1.00-4.99)	0.05	1.21 (0.15-9.69)	0.86	3.30 (1.63-6.68)	0.001	2.52 (1.53-4.15)	<0.001	
Socioeconomic status									
Poor	1.08 (0.48-2.42)	0.85	0.44 (0.05-3.76)	0.45	1.05 (0.48-2.33)	0.90	0.94 (0.55-1.59)	0.81	0.40
Next poor	0.74 (0.32-1.72)	0.49	1.03 (0.27-3.86)	0.97	0.72 (0.30-1.70)	0.45	0.73 (0.42-1.24)	0.24	
Average	0.91 (0.43-1.94)	0.81	0.50 (0.10-2.61)	0.41	0.73 (0.32-1.70)	0.47	0.73 (0.43-1.24)	0.25	
Next rich	1.14 (0.59-2.23)	0.70	1.33 (0.40-4.40)	0.64	0.81 (0.36-1.85)	0.62	0.99 (0.61-1.59)	0.96	
Rich	1.00		1.00		1.00		1.00		
Boys	0.80 (0.49-1.31)	0.37	1.45 (0.56-3.75)	0.45	1.91 (1.11-3.29)	0.02	1.24 (0.89-1.74)	0.21	
ANC attendance	0.58 (0.26-1.29)	0.18	1.40 (0.18-10.67)	0.74	0.61 (0.33-1.13)	0.11	0.71 (0.45-1.13)	0.15	
Twins	1.46 (0.58-3.68)	0.42	5.05 (1.12-22.66)	0.04	3.70 (1.57-8.73)	0.003	2.65 (1.48-4.73)	0.001	
First birth	0.52 (0.28-0.99)	0.05	0.35 (0.08-1.51)	0.16	0.91 (0.45-1.86)	0.80	0.67 (0.43-1.04)	0.08	
Parity									
1	1.00		1.00		1.00		1.00		
2	1.85 (0.79-4.30)	0.16	1.97 (0.33-11.88)	0.46	0.61 (0.18-2.09)	0.43	1.28 (0.68-2.43)	0.45	0.02
3	2.19 (0.93-5.20)	0.07	2.81 (0.51-15.42)	0.24	1.49 (0.57-3.94)	0.42	1.84 (1.01-3.36)	0.05	
4+	2.13 (1.02-4.45)	0.04	3.23 (0.69-15.02)	0.14	1.45 (0.64-3.28)	0.38	1.76 (1.05-2.93)	0.03	
Year of birth									
2005	1.00		1.00		1.00		1.00		
2006	0.76 (0.25-2.28)	0.62	0.23 (0.02-2.54)	0.23	0.60 (0.19-1.89)	0.38	0.58 (0.27-1.24)	0.16	0.12
2007	0.41 (0.12-1.40)	0.16	0.98 (0.19-5.09)	0.98	0.95 (0.35-2.55)	0.91	0.75 (0.38-1.47)	0.40	
2008	1.04 (0.42-2.60)	0.93	0.67 (0.11-4.08)	0.67	1.17 (0.45-3.02)	0.75	1.09 (0.59-2.02)	0.78	
2009	1.23 (0.52-2.93)	0.64	0.62 (0.10-3.74)	0.60	1.97 (0.82-4.73)	0.13	1.50 (0.84-2.68)	0.18	
2010	0.73 (0.29-1.85)	0.51	0.85 (0.15-4.70)	0.85	0.90 (0.32-2.49)	0.84	0.90 (0.48-1.69)	0.73	
Weekend	1.05 (0.61-1.80)	0.87	1.74 (0.67-4.51)	0.26	1.12 (0.64-1.95)	0.70	1.15 (0.81-1.65)	0.44	

Table 4.4.5: Multivariable logistic regression of factors associated with neonatal mortality in Kintampo (complete cases analyses)

	Hospital (n=2,953)		Clinic (n=1,477)		Home (n=4,732)		Overall (N=9,162)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of delivery									
Hospital	-		-		-		1.72 (1.57-1.88)	<0.001	
Clinic	-		-		-		1.27 (1.24-1.31)	<0.001	
Home	-		-		-		1.00		
Maternal age (years)									
<20	1.04 (0.28-3.85)	0.95	1.57 (0.13-18.74)	0.72	1.02 (0.19-5.56)	0.98	1.07 (0.90-1.25)	0.42	
20-29	1.00		1.00		1.00		1.00		
30-39	1.25 (0.61-2.57)	0.53	0.91 (0.27-3.13)	0.89	1.68 (0.77-3.68)	0.20	1.35 (1.00-1.82)	0.05	
40+	1.74 (0.56-5.36)	0.34	0.58 (0.05-6.49)	0.66	4.55 (1.82-11.37)	0.001	2.64 (1.15-6.08)	0.02	
Socioeconomic status									
Poor	1.38 (0.52-3.66)	0.51	0.48 (0.06-4.26)	0.51	1.24 (0.50-3.08)	0.65	1.20 (0.91-1.59)	0.21	
Next poor	1.03 (0.39-2.71)	0.95	0.79 (0.18-3.46)	0.76	0.85 (0.32-2.22)	0.73	0.94 (0.78-1.12)	0.48	
Average	1.43 (0.60-3.41)	0.42	0.40 (0.07-2.18)	0.29	0.81 (0.32-2.09)	0.66	0.99 (0.60-1.65)	0.98	
Next rich	1.62 (0.74-3.57)	0.23	1.28 (0.38-4.30)	0.69	0.93 (0.36-2.38)	0.88	1.28 (0.86-1.91)	0.23	
Rich	1.00		1.00		1.00		1.00		
Boys	0.95 (0.54-1.68)	0.87	1.77 (0.64-4.91)	0.27	1.69 (0.95-3.04)	0.08	1.33 (0.86-2.04)	0.20	
ANC attendance	0.52 (0.23-1.20)	0.13	1.83 (0.23-14.67)	0.57	0.65 (0.34-1.23)	0.18	0.65 (0.50-0.84)	0.001	
Twins	0.80 (0.19-3.42)	0.76	6.16 (1.18-32.27)	0.03	4.07 (1.54-10.76)	0.01	2.12 (0.66-6.77)	0.20	
Parity									
1	1.00		1.00		1.00		1.00		
2	1.98 (0.77-5.08)	0.16	2.24 (0.29-17.36)	0.44	1.00 (0.22-4.48)	1.00	1.62 (1.06-2.48)	0.03	
3	2.26 (0.83-6.12)	0.11	2.25 (0.27-18.42)	0.45	1.90 (0.49-7.38)	0.36	1.99 (1.74-2.29)	<0.001	
4+	1.21 (0.43-3.42)	0.72	3.59 (0.48-27.04)	0.21	1.08 (0.29-4.08)	0.91	1.31 (0.82-2.10)	0.26	
Year of birth									
2005	1.00		1.00		1.00		1.00		
2006	0.30 (0.08-1.10)	0.07	0.09 (0.01-1.17)	0.07	0.38 (0.11-1.35)	0.14	0.31 (0.21-0.46)	<0.001	
2007	0.23 (0.06-0.82)	0.03	0.45 (0.08-2.64)	0.38	0.55 (0.18-1.71)	0.30	0.42 (0.23-0.79)	0.01	
2008	0.41 (0.15-1.16)	0.09	0.32 (0.05-2.15)	0.24	0.64 (0.21-1.96)	0.44	0.51 (0.34-0.75)	<0.01	
2009	0.57 (0.22-1.49)	0.25	0.31 (0.05-2.04)	0.22	1.13 (0.40-3.17)	0.82	0.72 (0.40-1.28)	0.26	
2010	0.34 (0.12-0.97)	0.04	0.35 (0.05-2.32)	0.28	0.59 (0.18-1.89)	0.37	0.45 (0.30-0.67)	<0.001	
Weekend	0.89 (0.47-1.69)	0.72	1.76 (0.62-4.98)	0.28	0.75 (0.38-1.45)	0.39	0.93 (0.71-1.23)	0.63	

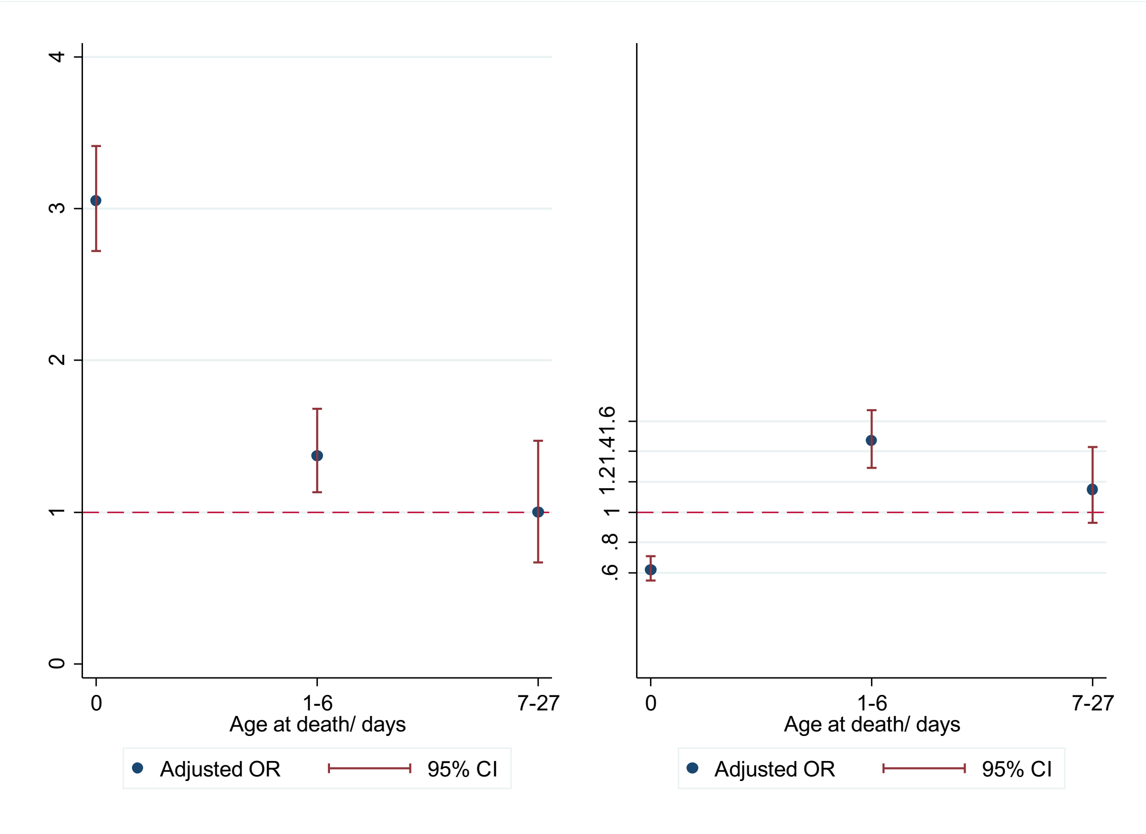
Table 4.4.6: Univariate logistic regression of factors related to neonatal mortality in Kintampo using multiple imputations by chained equations

	Hospital (n=3,634)		Clinic (n=1,790)		Home (n=5,783)		Overall (N=11,207)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of delivery									
Hospital							1.77 (1.24-2.53)	<0.01	
Clinic	-		-		-		1.00 (0.59-1.71)	0.99	
Home	-		-		-		1.00		
Maternal age (years)									
<20	0.63 (0.19-2.09)	0.45	0.66 (0.08-5.23)	0.69	1.11 (0.38-3.27)	0.85	0.81 (0.39-1.71)	0.59	0.001
20-29	1.00		1.00		1.00		1.00		
30-39	1.38 (0.80-2.38)	0.25	1.24 (0.46-3.37)	0.67	1.32 (0.71-2.44)	0.38	1.32 (0.91-1.93)	0.14	
40+	2.25 (1.01-5.02)	0.05	1.22 (0.15-9.71)	0.85	3.30 (1.63-6.68)	<0.01	2.52 (1.53-4.16)	<0.001	
Socioeconomic status									
Poor	1.08 (0.48-2.41)	0.86	0.44 (0.05-3.76)	0.45	1.05 (0.48-2.33)	0.90	0.93 (0.55-1.58)	0.80	0.38
Next poor	0.75 (0.33-1.74)	0.51	1.03 (0.27-3.86)	0.97	0.72 (0.30-1.70)	0.45	0.73 (0.42-1.25)	0.25	
Average	0.90 (0.42-1.92)	0.79	0.50 (0.10-2.61)	0.41	0.73 (0.32-1.70)	0.47	0.73 (0.43-1.23)	0.23	
Next rich	1.14 (0.58-2.22)	0.71	1.33 (0.40-4.41)	0.64	0.81 (0.36-1.85)	0.62	0.98 (0.61-1.58)	0.95	
Rich	1.00		1.00		1.00		1.00		
Boys	0.80 (0.49-1.31)	0.37	1.45 (0.56-3.75)	0.45	1.91 (1.11-3.29)	0.02	1.24 (0.89-1.74)	0.21	
ANC attendance	0.55 (0.25-1.21)	0.13	1.40 (0.18-10.68)	0.74	0.62 (0.33-1.16)	0.14	0.71 (0.44-1.13)	0.14	
Twins	1.50 (0.60-3.79)	0.87	5.01 (1.12-22.48)	0.04	3.70 (1.57-8.72)	<0.01	2.67 (1.50-4.77)	<0.01	
First birth	0.52 (0.28-0.99)	0.05	0.35 (0.08-1.51)	0.16	0.91 (0.45-1.86)	0.80	0.67 (0.43-1.04)	0.08	
Parity									
1	1.00		1.00		1.00		1.00		
2	1.87 (0.80-4.38)	0.15	1.98 (0.33-11.94)	0.45	0.51 (0.15-1.71)	0.27	1.21 (0.65-2.27)	0.57	0.05
3	2.23 (0.94-5.27)	0.07	2.80 (0.51-15.39)	0.24	1.28 (0.49-3.35)	0.61	1.74 (0.96-3.16)	0.07	
4+	2.08 (0.99-4.35)	0.05	3.24 (0.70-15.07)	0.13	1.17 (0.54-2.54)	0.69	1.59 (0.97-2.62)	0.07	
Year of birth									
2005	1.00		1.00		1.00		1.00		
2006	0.76 (0.25-2.28)	0.62	0.23 (0.02-2.54)	0.23	0.60 (0.19-1.89)	0.38	0.58 (0.27-1.24)	0.16	
2007	0.41 (0.12-1.40)	0.16	0.98 (0.19-5.09)	0.98	0.95 (0.35-2.55)	0.91	0.75 (0.38-1.47)	0.40	
2008	1.04 (0.42-2.60)	0.93	0.67 (0.11-4.08)	0.67	1.17 (0.45-3.02)	0.75	1.09 (0.59-2.02)	0.78	
2009	1.23 (0.52-2.93)	0.64	0.62 (0.10-3.74)	0.60	1.97 (0.82-4.73)	0.13	1.50 (0.84-2.68)	0.18	
2010	0.73 (0.29-1.85)	0.51	0.85 (0.15-4.70)	0.85	0.90 (0.32-2.49)	0.84	0.90 (0.48-1.69)	0.73	
Weekend	1.05 (0.61-1.80)	0.87	1.74 (0.67-4.51)	0.26	1.12 (0.64-1.95)	0.70	1.15 (0.81-1.65)	0.44	

Table 4.4.7: Multivariable logistic regression of factors related to neonatal mortality in Kintampo using multiple imputations by chained equations

	Hospital (n=3,634)		Clinic (n=1,790)		Home (n=5,783)		Overall (N=11,207)		P for trend
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	
Place of delivery									
Hospital	-		-		-		1.76 (1.55-2.00)	<0.001	
Clinic	-		-		-		1.12 (1.06-1.18)	<0.001	
Home	-		-		-		1.00		
Maternal age (years)									
<20	0.81 (0.22-2.96)	0.75	1.59 (0.14-17.82)	0.71	0.87 (0.26-2.98)	0.83	0.95 (0.75-1.20)	0.65	0.01
20-29	1.00		1.00		1.00		1.00		
30-39	1.28 (0.67-2.44)	0.46	0.94 (0.29-3.03)	0.92	1.41 (0.68-2.92)	0.35	1.28 (1.02-1.62)	0.04	
40+	2.08 (0.82-5.28)	0.13	0.81 (0.09-7.70)	0.86	3.85 (1.65-8.97)	<0.01	2.62 (1.44-4.78)	<0.01	
Socioeconomic status									
Poor	1.03 (0.45-2.35)	0.94	0.41 (0.05-3.67)	0.43	1.03 (0.46-2.30)	0.95	0.96 (0.82-1.14)	0.67	0.15
Next poor	0.71 (0.31-1.66)	0.43	0.97 (0.25-3.77)	0.96	0.69 (0.29-1.64)	0.40	0.76 (0.65-0.88)	<0.001	
Average	0.89 (0.42-1.91)	0.77	0.44 (0.08-2.32)	0.33	0.68 (0.29-1.58)	0.37	0.75 (0.58-0.96)	0.03	
Next rich	1.10 (0.56-2.16)	0.78	1.25 (0.37-4.18)	0.72	0.83 (0.36-1.91)	0.66	1.01 (0.79-1.29)	0.93	
Rich	1.00		1.00		1.00		1.00		
Boys	0.80 (0.49-1.32)	0.39	1.48 (0.56-3.88)	0.43	1.93 (1.12-3.34)	0.02	1.24 (0.66-2.33)	0.51	
ANC attendance	0.55 (0.24-1.25)	0.16	1.62 (0.20-12.93)	0.65	0.67 (0.36-1.25)	0.21	0.66 (0.49-0.90)	0.01	
Twins	1.43 (0.55-3.75)	0.46	4.54 (0.90-22.79)	0.07	4.08 (1.68-9.92)	<0.01	2.48 (1.08-5.66)	0.03	
Parity									
1	1.00		1.00		1.00		1.00		
2	1.60 (0.63-4.05)	0.32	2.30 (0.31-17.06)	0.42	0.48 (0.13-1.71)	0.26	1.17 (0.51-2.67)	0.72	0.95
3	1.77 (0.66-4.73)	0.26	3.13 (0.43-22.71)	0.26	1.04 (0.35-3.04)	0.95	1.55 (0.92-2.63)	0.10	
4+	1.36 (0.52-3.57)	0.53	3.51 (0.49-24.98)	0.21	0.62 (0.22-1.77)	0.38	1.13 (0.54-2.39)	0.74	
Year of birth									
2005	1.00		1.00		1.00		1.00		
2006	0.76 (0.25-2.32)	0.64	0.20 (0.02-2.32)	0.20	0.58 (0.18-1.85)	0.36	0.60 (0.41-0.90)	0.01	0.04
2007	0.40 (0.12-1.40)	0.15	1.00 (0.19-5.37)	1.00	0.96 (0.35-2.60)	0.93	0.77 (0.43-1.39)	0.39	
2008	1.03 (0.41-2.60)	0.94	0.65 (0.10-4.11)	0.65	1.14 (0.44-2.98)	0.79	1.06 (0.89-1.27)	0.50	
2009	1.27 (0.53-3.04)	0.60	0.64 (0.10-3.94)	0.63	2.12 (0.87-5.13)	0.10	1.46 (0.93-2.29)	0.10	
2010	0.69 (0.27-1.77)	0.45	0.84 (0.15-4.81)	0.85	0.89 (0.32-2.48)	0.82	0.82 (0.68-1.00)	0.05	

Weekend	1.02 (0.59-1.77)	0.93	1.79 (0.68-4.73)	0.24	1.04 (0.59-1.83)	0.90	1.14 (0.96-1.36)	0.14	
1 (p=0.01)									



Left- Hospital births, Right- Clinic births, Reference line- Home births

Fig 4.4.3: Forest plot of adjusted* odds ratio for the association between place of birth and neonatal mortality, according to age at death.

The graph in Fig 4.4.3 shows subgroup analysis of the association between place of birth and neonatal mortality. The graph shows that compared to home births (reference line), hospital births had a significant higher risk of deaths on the day of birth (day 0) and over days 1-6 but not thereafter. Compared to home births, clinic births had a significantly lower risk of deaths on day 0, but a higher risk of death over days 1-6. The association between clinic births and late neonatal deaths was not statistically significant.

4.4.4 Neonatal deaths in Kintampo

4.4.4.1 Age at death

Overall, 140 babies died within 28 days (0-27 days) of birth in Kintampo. Of these 103 (73.6%) died over days 0-6 representing an NMR of 9.2 and 37 (26.4%) died over days 7-27 representing an NMR of 3.3. Of the deaths in the first week (0-6 days), 55 (53.4%) died on the day of birth, representing an NMR of 4.9.

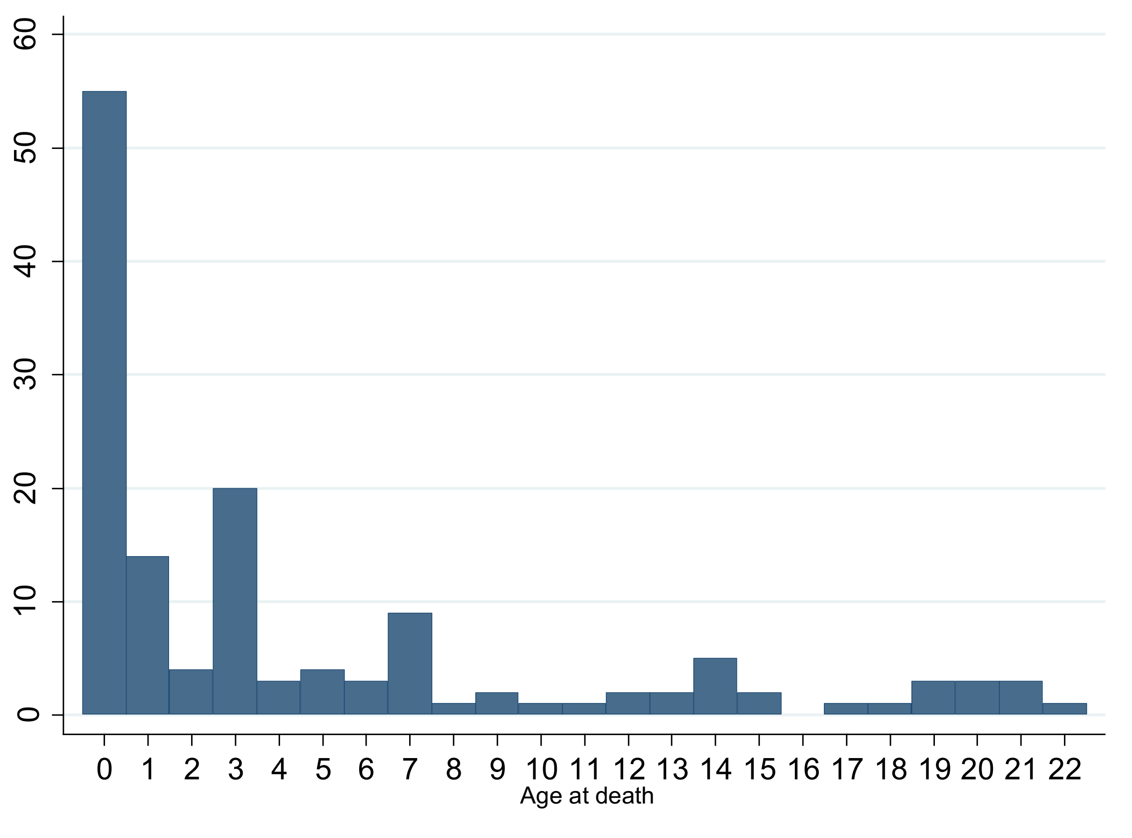


Fig 4.4.4: Distribution of neonatal deaths by age at death (days)

Fig 4.4.4 depicts the distribution of neonatal deaths in Kintampo by age of baby at death. The bar graph shows that the vast majority (n=103, 74%) of neonatal deaths occurred within 7 days of birth, with 53% of these occurring on day 0. The numbers of babies who died reduced over time and there were no neonatal deaths recorded after day 22.

Place of birth and death among neonatal deaths

Table 4.4.9 shows the distribution of neonatal deaths by place of birth and place of death. Overall, 82 (58.6%) neonatal deaths followed deliveries in a health facility (hospital or clinic) and 58 (41.4%) were born at home. The table shows that a higher number and proportion of babies who were born in a health facility died at home or other places (n=24, 30%) compared to those who were born at home but died in a health facility (n=10, 18%), especially for babies who died on the day of birth and those who died after the first week (days 7-27). The differences were statistically significant (p<0.001). When stratified by place of birth and place of death, babies who were both born and died in a health facility had the highest NMR of 10.5. Those who were born at home and also died at home had a NMR of 7.8. Babies who were born in a health facility but died at home had a NMR of 4.4 and those who were born at home but died in a health facility had a NMR of 1.7

When babies who died in a different location from where they were born (those born in a health facility but died at home and those born at home but died in health facility) were excluded from the sample, a multivariable logistic regression analysis showed that babies who were born in hospital or clinic remained at an increased risk of death in a health facility compared to babies who were born at home (adjusted OR 1.22, 95% CI 1.16-1.29, $p<0.001$).

Table 4.4.9: Distribution of neonatal deaths by place of birth and place of death

	Place of birth			
Place of death	**Hospital/ Clinic (n=82)**	**Home (n=58)**	**Total (N=140)**	**p-value**
	n (%)	**n (%)**	**N (%)**	
All deaths (n=140)				
Hospital/Clinic	57 (70.4)	10 (18.2)	67 (49.3)	<0.001
Home/Other	24 (29.6)	45 (81.8)	69 (50.7)	
Missing	1	3	4	
Day 0 (n=55)				
Hospital/Clinic	33 (89.2)	0	33 (61.1)	<0.001
Home/Other	4 (10.8)	17 (100.0)	21 (38.9)	
Missing	0	1	1	
Days 1-6 (n=48)				
Hospital/Clinic	15 (57.7)	7 (35.0)	22 (47.8)	0.13
Home/Other	11 (42.3)	13 (65.0)	24 (52.2)	
Missing	0	2	2	
Days 7-27 (n=37)				
Hospital/Clinic	9 (50.0)	3 (16.7)	12 (33.3)	0.03
Home/Other	9 (50.0)	15 (83.3)	24 (66.7)	
Missing	1	0	1	

Age of neonate at death by place of birth, stratified by place of death

Table 4.4.10 shows the distribution of neonatal deaths by age at death. Overall, a higher proportion of babies born in a hospital or clinic died on the day of birth and a higher proportion of babies born at home died after the first day. Among babies who died in a hospital or clinic, those who were born in a hospital or clinic were significantly more likely to die on the day of birth (day 0) and those who were born at home were more likely to die after the first day.

Table 4.4.10: Distribution of neonatal deaths by place of birth and age at death

Place of death	Place of birth			
	Hospital/ Clinic	Home	Total	p-value
Age (days) at death	n (%)	n (%)	N (%)	
All deaths (n=140)				
0	37 (45.1)	18 (31.0)	55 (39.3)	0.24
1-6	26 (31.7)	22 (37.9)	48 (34.3)	
7-27	19 (23.2)	18 (31.0)	37 (26.4)	
Hospital/clinic (n=67)				
0	33 (57.9)	0	33 (49.3)	<0.01
1-6	15 (26.3)	7 (70.0)	22 (32.8)	
7-27	9 (15.8)	3 (30.0)	12 (17.9)	
Home (n=69)				
0	4 (16.7)	17 (37.8)	21 (30.4)	0.16
1-6	11 (45.8)	13 (28.9)	24 (34.8)	
7-27	9 (37.5)	15 (33.3)	24 (34.8)	

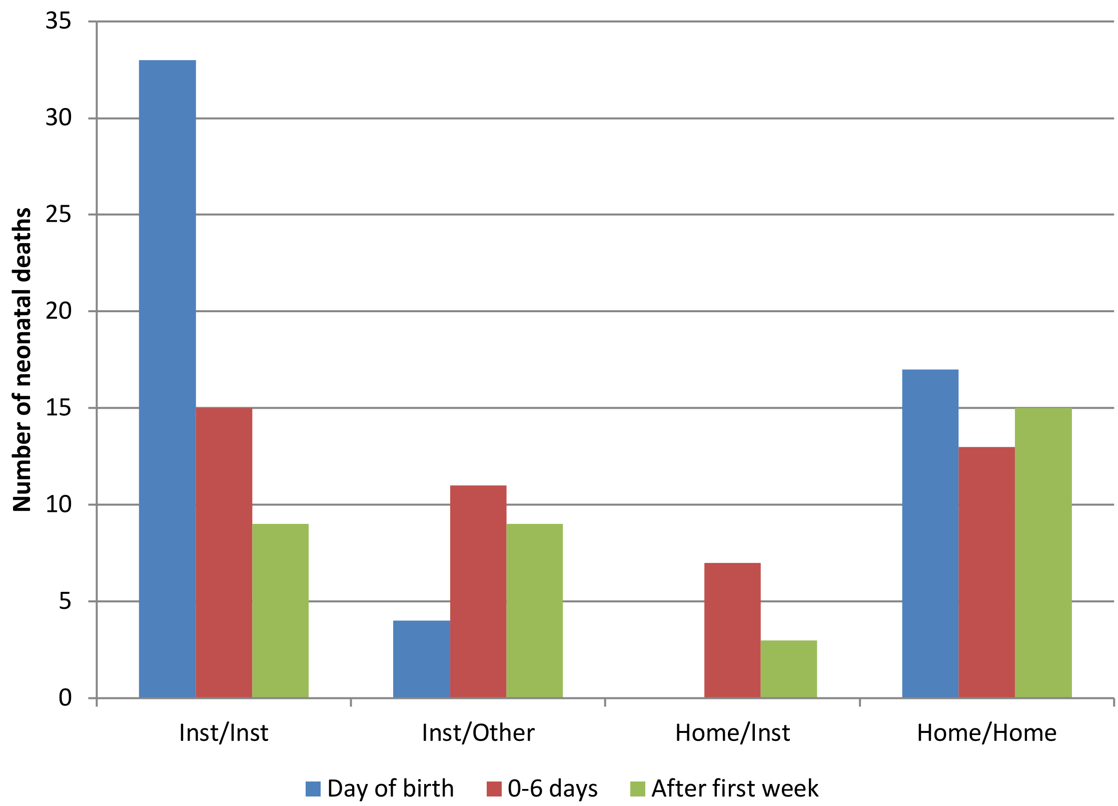


Fig 4.4.5: Number of neonatal deaths by place of birth and place of death according age at death

The bar graph in Fig 4.4.5 shows the age distribution of neonatal deaths according to where the baby was born/where the baby died. The graph shows that among babies who were born in a hospital or clinic (institutional birth) and also died in the hospital or clinic (institutional death), most of them died on the day of birth, but among babies who were born at home and also died at home

(home/home), the proportions of death were distributed more equally across the neonatal periods. Four babies (20%) who were born in a health facility died at home on the same day they were born, but none of the babies born at home died in a health facility on the day they were born.

Causes of neonatal death

The leading causes of neonatal mortality in Kintampo were asphyxia (n=34, 24%), infection (n=34, 24%), anaemia and other unspecified causes (n=30, 21%) and prematurity and low birth weight (n=7, 5%). The cause specific NMR (CSNMR) was as follows: asphyxia - 3.0, infection - 3.0, prematurity and low birth weight - 0.6, and others - 2.6.

Cause of death by age at death

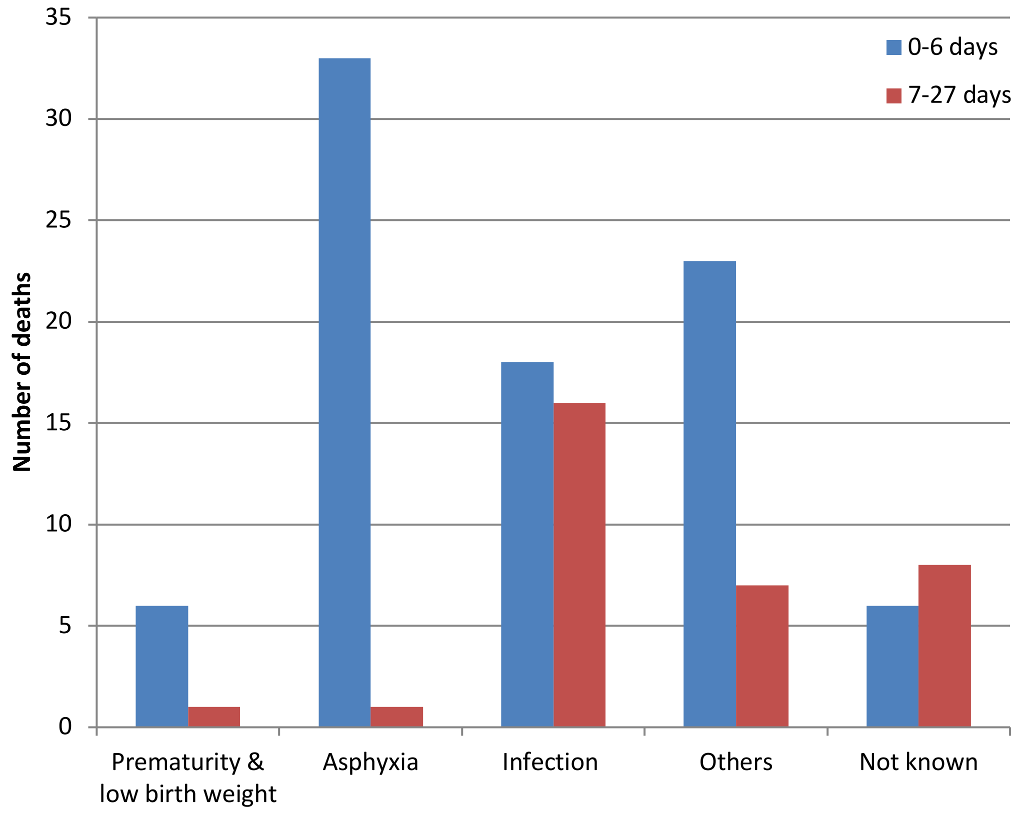


Fig 4.4.6: Causes of neonatal deaths by age at death

The bar graph in Fig 4.4.6 shows the causes of neonatal death by age at death. The graph shows that asphyxia was the leading cause of neonatal deaths over 0-6 days and it was responsible for 56% of day 0 deaths, and infection was the leading cause of late neonatal deaths. A chi square test showed that babies who died over days 0-6 were more likely to die of prematurity/ low birth weight or asphyxia, and babies who died over days 7-27 were more likely to die of infection (p<0.001)

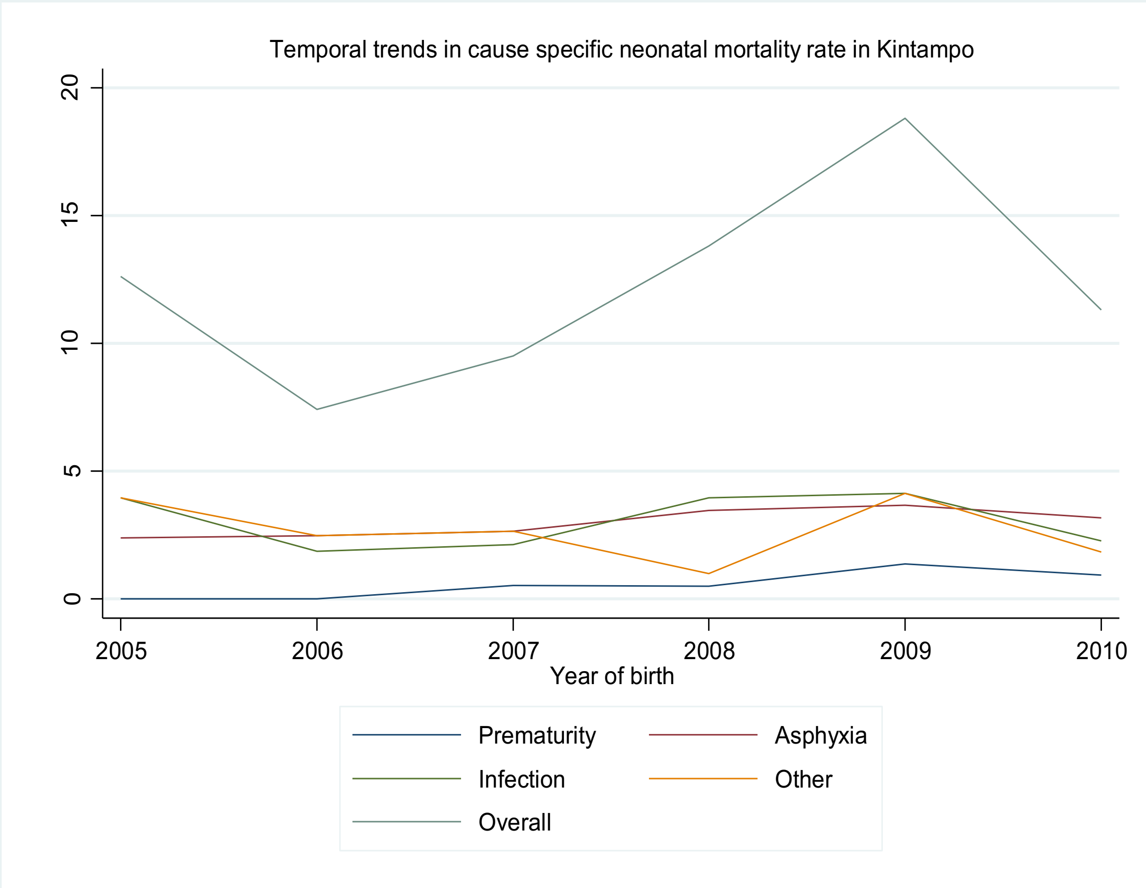


Fig 4.4.7: Cause specific NMR by year of birth in Kintampo accoridng to the cause of death

Fig 4.4.7 shows temporal trends in CSNMR in Kintampo according to the cause of death. The line graph shows that prematurity had the lowest NMR over the study period, and NMR due to the other causes overlapped.

Cause of neonatal death by place of birth and death

Table 4.4.11 shows the causes of neonatal deaths by place of birth and cause of death, stratified by age at death. The table shows that the leading cause of death among babies born in a hospital or clinic was asphyxia and the leading cause of death among babies born at home was infection. There was a large number of babies (n=15) whose cause of death was unknown or not coded. Among babies who died on the day of birth, asphyxia was the leading cause of death. Infection was the leading cause of death after day 0, for births both in a health facility and at home. There was no statistically significant difference in the cause of neonatal death by place of birth.

Table 4.4.11: Cause of death by place of birth and age at death

	Place of birth			
	Hospital/ Clinic	Home	Total	p-value
All deaths (n=140)				
Prematurity & LBW	5 (7.5)	2 (3.9)	7 (5.9)	0.10
Asphyxia	22 (32.8)	12 (23.1)	34 (28.6)	
Infection	16 (23.9)	18 (34.6)	34 (28.6)	
Others	13 (19.4)	17 (32.7)	30 (25.2)	
Not known	11 (16.4)	3 (5.8)	14 (11.8)	
Missing	15	6	21	
Day of birth (n=55)				
Prematurity & LBW	3 (10.3)	2 (12.5)	5 (11.1)	0.68
Asphyxia	16 (55.2)	9 (56.3)	25 (55.6)	
Infection	2 (6.9)	1 (6.3)	3 (6.7)	
Others	5 (17.2)	4 (25.0)	9 (20.0)	
Not known	3 (10.3)	0	3 (6.7)	
Missing	8	2	10	
1-6 days (n=48)				
Prematurity & LBW	1 (5.0)	0	1 (2.4)	0.74
Asphyxia	5 (25.0)	3 (14.3)	8 (19.5)	
Infection	6 (30.0)	9 (42.9)	15 (36.6)	
Others	5 (25.0)	9 (42.9)	14 (34.2)	
Not known	3 (15.0)	0	3 (7.3)	
Missing	6	1	7	
Days 7-27 (n=37)				
Prematurity & LBW	1 (5.6)	0	1 (3.0)	0.83
Asphyxia	1 (5.6)	0	1 (3.0)	
Infection	8 (44.4)	8 (53.3)	16 (48.5)	
Others	3 (16.7)	4 (26.7)	7 (21.2)	
Not known	5 (27.8)	3 (20.0)	8 (24.2)	
Missing	1	3	4	

Table 4.4.12 shows the distribution of neonatal deaths by place of death. Nearly equal proportions of babies died in a hospital or clinic and at home. The table shows a significant difference in the age at which babies died by place of death. Babies who died on the day they were born were more likely to die in a hospital or clinic and those who died after the first day were more likely to die at home. Asphyxia was the leading cause of death among babies who died in a hospital or clinic (35.7%) and infection was the leading cause of death among those who died at home (31.2%) but the difference was not statistically significant.

Table 4.4.12: Characteristics of neonatal deaths by place of death

	Place of death			
	Hospital/clinic	Home/other	Total	p-value
	n=67	n=69	N=136	
Day of death				
0	33 (49.3)	21 (30.4)	54 (39.7)	0.04
1-6	22 (32.8)	24 (34.8)	46 (33.8)	
7-27	12 (17.9)	24 (34.8)	36 (26.5)	
Cause of death				
Prematurity & LBW	4 (7.1)	3 (5.0)	7 (6.0)	0.54
Asphyxia	20 (35.7)	14 (23.3)	34 (29.3)	
Infection	14 (25.0)	19 (31.7)	33 (28.5)	
Others	11 (19.6)	17 (28.3)	28 (24.1)	
Not known	7 (12.5)	7 (11.7)	14 (12.1)	

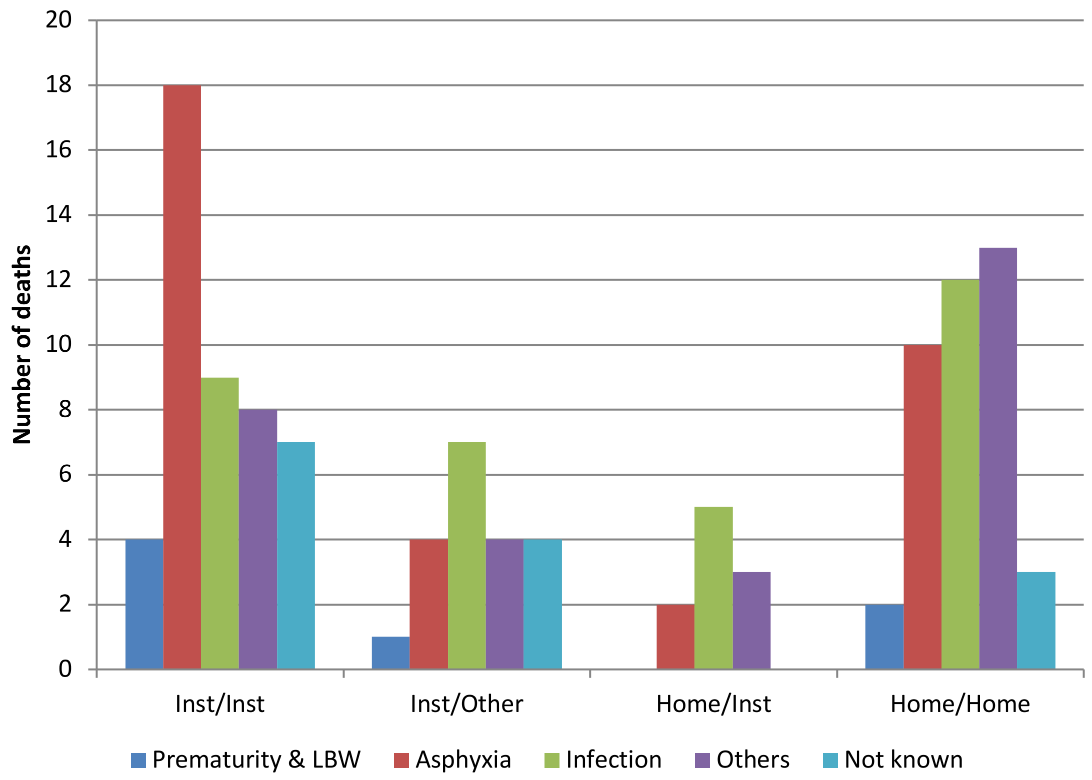


Fig 4.4.8: Causes of neonatal deaths by place of birth and place of death

The bar graph in Fig 4.4.8 shows the distribution of the causes of neonatal deaths in Kintampo, according to where the baby was born and where the baby died. Overall, the leading cause of death among babies who died in a health facility was asphyxia (n=20, 35.7%) and the leading cause of death among babies who died at home was infection (n=19, 31.7%). Among those who were born in a health facility but died at home and those who were born at home but died in a health facility, the largest proportion died of infection. The differences in cause of death by place of birth and death were not statistically significant.

Cause of death by selected risk factors

Table 4.4.13 shows the death profile of neonates in Kintampo according to factors identified as associated with neonatal mortality in the regression analyses. The table shows that babies born to older mothers were more likely to die from birth asphyxia and babies born to younger mothers were more likely to die from infection. Twins were more likely to die from asphyxia and singletons were more likely to die from infection. The differences in causes of death by the selected maternal characteristics were not statistically significant.

Table 4.4.13: Causes of neonatal death by selected risk factors

	Prematurity and low birth weight	Birth asphyxia	Infection	Others	Unknown	Total
Maternal age						
<20	0	2 (33.3)	3 (50.0)	1 (16.7)	0	6
20-29	3 (6.7)	12 (26.7)	11 (24.4)	12 (26.7)	7 (15.6)	45
30-39	4 (8.7)	13 (28.3)	14 (30.4)	9 (19.6)	6 (13.0)	46
40+	0	7 (33.3)	6 (28.6)	7 (33.3)	1 (4.8)	21
ANC						
Yes	6 (6.9)	22 (25.3)	25 (28.7)	24 (27.6)	10 (11.5)	87
No	0	6 (31.6)	5 (26.3)	5 (26.3)	3 (15.8)	19
Multiple birth						
No	5 (4.7)	29 (27.4)	33 (31.1)	29 (27.4)	10 (9.4)	106
Yes	2 (16.7)	5 (41.7)	1 (8.3)	1 (8.3)	3 (25.0)	12

4.5.4 Summary of key findings

Overall, the NMR in Kintampo was 12.5, with a 13% decline in NMR from 2005 to 2010. Hospital births had the highest NMR of 18, followed by home and clinic births which both had NMRs of 10. Overall, hospital and clinic births had a significantly higher risk of neonatal mortality compared to home births. When stratified by age at death, babies born in hospital had a higher risk of early neonatal death, comprising day 0 and days 1-6, and those born in clinics had a lower risk of death on the day of birth, but a higher risk of death over days 1-6 (compared to babies born at home). There was no difference in the risk of late neonatal deaths by place of delivery. Twins, babies of mothers over 30 years old and of those who did not attend a single episode of ANC had significantly higher risk of neonatal death, overall. Among babies born at home, boys had an apparently increased risk of neonatal death.

The majority of neonatal deaths in Kintampo occurred in the first week, especially on the day of birth, and the leading causes of early neonatal deaths were asphyxia and prematurity. Early neonatal deaths were more common in hospitals or clinic and late neonatal deaths were more common at home. The leading cause of death in hospital was asphyxia and the leading cause of death at home was infection.

Although babies born in a hospital or clinic were at higher risk of death compared to home births, this study found an excess of deaths occurring at home among babies born in a hospital or clinic, including deaths which occurred on the day of birth. The leading cause of death among babies who were both born and died in hospital or clinic was asphyxia and the leading cause of death among babies who died at home was infection.

4.5 The Dodowa health and demographic surveillance system

4.5.1 Dodowa HDSS data management

Electronic data extracts of the pregnancy outcome file (n=23,377), birth registration file (n=22,375), and VA file (n=104) from the Dodowa HDSS covering the years 2006-2014 inclusive were shared as three separate Stata (.dta) files. The birth registration file contained information on all livebirths in the Dodowa HDSS from 2006 to 2014 and the VA file contained supplementary information on those who died within 28 days of birth during the same period. The pregnancy outcome file contained episode level information of all women in the Dodowa HDSS whose pregnancy ended within the study period, regardless of the outcome. A large number (n=21,954) of these pregnancies resulted in a live birth; the rest ended in abortions (n=3), miscarriages (n=124), stillbirths (n=148), could not be followed up (1,076), or were found not to be pregnant (n=72). This study used information on only women whose pregnancies ended in a live birth.

The birth registration file and the VA file were merged using the unique neonatal identification numbers in both files. The resultant file, containing all the information on live and dead babies, was merged with information on mothers whose pregnancies ended in a live birth using the mother's identification code and baby's date of birth contained in both files. Since each mother had a unique identification code, mothers who had more than one child had repeated mother's IDs for each baby. Therefore, merging the mother and baby data using the mother's ID and the baby's date of birth ensured that each baby was merged with the correct maternal information. Mothers (n=607) whose information could not be linked with the baby, and babies (n=635) whose information could not be linked with mother were excluded from the study. Babies whose information was not linked with the mother were excluded because their place of birth was also unknown since this was recorded in the pregnancy outcome file. Of the 21,808 babies whose information was correctly linked with the mother, 161 were further excluded because their place of birth was not specified. The final dataset therefore contained 21,647 babies delivered in the Dodowa HDSS from 2006-2014.

4.5.2 Statistical analyses

Statistical methods used for the descriptive and analytical statistics have been described previously in 4.2.5. Multiple imputations modelling was used to create 45 additional datasets containing simulated values for missing data in the original dataset. The imputation model is given as; ice neonatal_mortality place_of_birth sex socioeconomic_status day_of_birth multiple_birth year_of_birth marital_status [*mlogit*] education [*mlogit*] parity [*mlogit*] first_birth [*logit*] religion [*mlogit*] ethnicity [*mlogit*] maternal_age [*mlogit*]

Univariate and multivariable logistic regression models were used to explore the associations between the explanatory variables and the binary outcome. Regression models were run on both complete cases and imputed datasets, overall and stratified by place of birth. All the logistic regression models were fitted using maximum likelihood estimation methods [*logit*] to compute the adjusted and unadjusted odds ratios, except for multivariable regression analyses of complete cases for babies born in clinics which used a penalised maximum likelihood regression model [*firthlogit*] because conventional maximum likelihood methods yielded exaggerated standard errors and could also not be estimated for some covariates. The multivariable models for the imputed data used the binary logistic regression model to estimate the adjusted odds ratios of mortality using Rubin's rules [*mim*]. The multivariable models were adjusted for maternal age, socioeconomic status, education, ethnicity, religion, marital status, sex, multiple birth, parity, day of birth and year of birth. First birth was excluded from the multivariable model because it was strongly correlated with parity. ANC could not be included in the multivariable model because it contained >50% missing data which would have reduced the sample size substantially and potentially introducing bias.

4.5.3 Results

Of the 21,647 livebirths delivered in the Dodowa HDSS from 2006-2014, 8,036 (37.1%) were delivered in hospital, 6,037 (27.9%) in a clinic and 7,574 (35%) at home. Tables 4.5.1-2 summarises the characteristics of babies by place of delivery and Tables 4.5.3-4 summarises the characteristics of the babies by neonatal mortality rate. Table 4.5.5 shows the temporal trends in neonatal mortality and Tables 4.5.6-13 shows the associations between the recorded explanatory variables and neonatal mortality.

4.5.3.1 Summary characteristics of mothers and babies in Dodowa by place of delivery

Table 4.5.1 describes the maternal demographic characteristics of babies delivered in Dodowa by place of delivery. The table shows statistically significant differences in maternal demographic characteristics by place of delivery. Babies born in hospital were the most likely to die within the neonatal period and those delivered in clinics were the least likely to die. The table reveals that, in Dodowa, a higher proportion of educated, rich, single or married and non-Dangbes delivered in hospital. Poor mothers, unemployed, Dangbes and Christian mothers were more likely to deliver in a clinic. Teenage mothers, and those over 40 years old, or who had no formal education, practised a Traditional religion, or were cohabiting were more likely to deliver at home.

Table 4.5.1: Summary of maternal characteristics in Dodowa by place of delivery

	Hospital n (%) (n=8,036)	Clinic n (%) (n=6,037)	Home n (%) (n=7,574)	Total n (%) (n=21,647)	p-value
Neonatal mortality					
Alive	7,969 (99.2)	6,013 (99.6)	7,530 (99.4)	21,512 (99.4)	<0.01
Dead	67 (0.8)	24 (0.4)	44 (0.6)	135 (0.6)	
Maternal age					
<20 years	923 (11.5)	675 (11.2)	979 (13.0)	2,577 (11.9)	<0.001
20-29	3,881 (48.4)	3,259 (54.1)	4,036 (53.4)	11,176 (51.8)	
30-39	2,717 (33.9)	1,791 (29.7)	2,052 (27.2)	6,560 (30.4)	
40+	499 (6.2)	301 (5.0)	485 (6.4)	1,285 (6.0)	
Missing	16	11	22	49	
Socioeconomic status					
Poor	1,562 (19.4)	1,270 (21.0)	1,451 (19.2)	4,283 (19.8)	<0.001
Next poor	1,100 (13.7)	1,062 (17.6)	2,214 (29.2)	4,376 (20.2)	
Average	1,394 (17.4)	1,073 (17.8)	1,907 (25.2)	4,374 (20.2)	
Next rich	1,715 (21.3)	1,269 (21.0)	1,337 (17.7)	4,321 (20.0)	
Rich	2,265 (28.2)	1,363 (22.6)	665 (8.8)	4,293 (19.8)	
Education					
None	1,679 (20.9)	1,696 (28.1)	2,956 (39.0)	6,331 (29.3)	<0.001
Basic	5,351 (66.6)	3,934 (65.2)	4,443 (58.7)	13,728 (63.4)	
Secondary or higher	1,004 (12.5)	407 (6.7)	172 (2.3)	1,583 (7.3)	
Missing	2	0	3	5	
Marital status					
Single	2,122 (27.0)	1,541 (26.0)	1,990 (26.8)	5,653 (26.6)	<0.001
Married	2,081 (26.4)	1,427 (24.1)	1,654 (22.3)	5,162 (24.3)	
Previous married	177 (2.3)	142 (2.4)	154 (2.1)	473 (2.2)	
Cohabiting	3,494 (44.4)	2,817 (47.5)	3,620 (48.8)	9,931 (46.8)	
Missing	162	110	156	428	
Ethnicity					
Ga-Dangbe	5,474 (68.2)	4,826 (80.0)	5,970 (78.9)	16,270 (75.2)	<0.001
Akan	575 (7.2)	289 (4.8)	111 (1.5)	975 (4.5)	
Ewe	1,426 (17.8)	635 (10.5)	1,188 (15.7)	3,249 (15.0)	
Northern	486 (6.1)	249 (4.1)	255 (3.4)	990 (4.6)	
Other	68 (0.9)	36 (0.6)	46 (0.6)	150 (0.7)	
Missing	7	2	4	13	
Religion					
Christianity	7,334 (91.3)	5,547 (92.0)	6,773 (89.5)	19,654 (90.9)	<0.001
Islam	545 (6.8)	312 (5.2)	386 (5.1)	1,243 (5.8)	
Traditional & others	151 (1.9)	172 (2.9)	409 (5.4)	732(3.4)	
Missing	6	6	6	18	

Table 4.5.2 summarises the delivery characteristics of mothers and characteristics of babies delivered in the Dodowa HDSS. The table shows that mothers who did not attend ANC were more likely to deliver at home and those who attended ANC were more likely to deliver in hospital. Of those who

attended ANC, mothers who attended less than four times and those who attended their booking visit in the last trimester were more likely to deliver at home and those who attended four times or more and attended booking visit in the first trimester were more likely to deliver in hospital. A higher proportion of hospital births were twins, first births or delivered on a weekday. A higher proportion of home births was singletons, or delivered on a weekend. Most babies were delivered by a midwife in a hospital or clinic and most babies delivered at home by a TBA. There was no statistically significant difference in the sex of babies by place of delivery.

Table 4.5.2: Summary of delivery and neonatal characteristics by place of birth

	Hospital (n=8,036) n (%)	Clinic (n=6,037) n (%)	Home (n=7,574) n (%)	Total (n=21,647) n (%)	p-value
ANC					
No	23 (0.5)	17 (0.6)	174 (6.0)	214 (2.1)	<0.001
Yes	4,494 (99.5)	2,743 (99.4)	2,705 (94.0)	9,942 (97.9)	
Missing	3,519	3,277	4,695	11,491	
Number of ANC					
0=no ANC	23 (0.5)	17 (0.6)	174 (6.1)	214 (2.1)	<0.001
1	51 (1.1)	41 (1.5)	172 (6.0)	264 (2.6)	
2	120 (2.7)	91 (3.3)	245 (8.5)	456 (4.5)	
3	301 (6.7)	243 (8.8)	449 (15.6)	993 (9.8)	
4+	4,012 (89.0)	2,359 (85.8)	1,829 (63.8)	8,200 (81.0)	
Missing	3,552	3,303	4,879	11,734	
Booking visit					
0=no ANC	23 (0.5)	17 (0.6)	174 (6.1)	214 (2.1)	<0.001
1-3 months	2,668 (59.2)	1,530 (55.6)	1,263 (44.0)	5,461 (53.9)	
3-6 months	1,641 (36.4)	1,113 (40.5)	1,222 (42.6)	3,976 (39.3)	
7+ months	176 (3.9)	91 (3.3)	211 (7.4)	478 (4.7)	
Missing	3,528	3,286	4,704	11,518	
Staff at delivery					
Doctor	741 (16.4)	42 (1.5)	8 (0.3)	791 (7.8)	<0.001
Midwife/Nurse	3,756 (83.1)	2,688 (97.3)	195 (6.8)	6,639 (65.3)	
TBA	7 (0.2)	18 (0.7)	1,778 (61.8)	1,803 (17.8)	
Relative	4 (0.1)	8 (0.3)	690 (24.0)	702 (6.9)	
Other	3 (0.1)	2 (0.1)	29 (1.0)	34 (0.3)	
No one	8 (0.2)	4 (0.1)	179 (6.2)	191 (1.9)	
Missing	3,517	3,275	4,695	11,487	
Sex					
Female	3,828 (47.6)	2,977 (49.3)	3,687 (48.7)	10,492 (48.5)	0.13
Male	4,208 (52.4)	3,060 (50.7)	3,887 (51.3)	11,155 (51.5)	
Multiple birth					
No	7,506 (93.4)	5,845 (96.8)	7,366 (97.3)	20,717 (95.7)	<0.001
Yes	530 (6.6)	192 (3.2)	208 (2.8)	930 (4.3)	
First birth					
Yes	2,817 (35.1)	1,617 (26.8)	1,594 (21.1)	6,028 (27.9)	<0.001
No	5,216 (64.9)	4,417 (73.2)	5,977 (79.0)	15,610 (72.1)	
Missing	3	3	3	9	
Parity					
1	938 (15.3)	519 (10.5)	387 (6.1)	1,844 (10.6)	<0.001
2	1,719 (28.0)	1,491 (30.3)	1,878 (29.6)	5,088 (29.2)	
3	1,360 (22.1)	1,157 (23.5)	1,362 (21.5)	3,879 (22.3)	
4+	2,125 (34.6)	1,755 (35.7)	2,722 (42.9)	6,602 (37.9)	
Missing	1,894	1,115	1,225	4,234	
Day of birth					
Weekday	5,914 (73.6)	4,372 (72.4)	5,440 (71.8)	15,726 (72.7)	0.04
Weekend	2,122 (26.4)	1,665 (27.6)	2,134 (28.2)	5,921 (27.4)	

4.5.3.2 Neonatal mortality and neonatal mortality rate in Dodowa

Table 4.5.3 summarises the NMR by the characteristics of mothers. Overall, 135 out of 21,647 livebirths died within the neonatal period, representing a NMR of 6.2. Hospital births had the highest NMR of 8.3, followed by 5.8 for home births and 4.0 for clinic births. The table also shows there were significant differences in NMR by place of delivery, maternal education and ethnicity. Mothers who delivered in hospital and those who had no formal education were more likely to lose their babies in the neonatal period (NMR=7.4).

Table 4.5.3: Summary of maternal characteristics in Dodowa by neonatal mortality

	Total livebirths n (%)	Dead n (%)	NMR	P-value
Dodowa- All	21,647 (100.0)	135 (0.6)	6.2	
Place of birth				
Hospital	8,036 (37.1)	67 (49.6)	8.3	<0.01
Clinic	6,037 (27.9)	24 (17.8)	4.0	
Home	7,574 (35.0)	44 (32.6)	5.8	
Maternal age				
<20 years	2,577 (11.9)	9 (6.7)	3.5	0.07
20-29	11,176 (51.8)	69 (51.1)	6.2	
30-39	6,560 (30.4)	48 (35.6)	7.3	
40+	1,285 (6.0)	9 (6.7)	7.0	
Missing	49	0		
Socioeconomic status				
Poor	4,283 (19.8)	10 (7.4)	2.3	0.29
Next poor	4,376 (20.2)	41 (30.4)	9.4	
Average	4,374 (20.2)	31 (23.0)	7.1	
Next rich	4,321 (20.0)	28 (20.7)	6.5	
Rich	4,293 (19.8)	25 (18.5)	5.8	
Education				
None	6,331 (29.3)	47 (34.8)	7.4	0.03
Basic	13,728 (63.4)	84 (62.2)	6.1	
Secondary or higher	1,583 (7.3)	4 (3.0)	2.5	
Missing	5	0		
Marital status				
Single	5,653 (26.6)	40 (29.9)	7.1	0.09
Married	5,162 (24.3)	40 (29.9)	7.7	
Previous married	473 (2.2)	5 (3.7)	10.6	
Cohabiting	9,931 (46.8)	49 (36.6)	4.9	
Missing	428	1		
Ethnicity				
Ga-Dangbe	16,270 (75.2)	112 (83.0)	6.9	<0.01
Akan	975 (4.5)	3 (2.2)	3.1	
Ewe	3,249 (15.0)	13 (9.6)	4.0	
Northern	990 (4.6)	3 (2.2)	3.0	
Other	150 (0.7)	4 (3.0)	26.7	
Missing	13	0		
Religion				
Christianity	19,654 (90.9)	124 (91.9)	6.3	0.92
Islam	1,243 (5.8)	7 (5.2)	5.6	
Traditional and Other	732 (3.4)	4 (3.0)	5.5	
Missing	18	0		

Table 4.5.4 summarises the NMR by the delivery and neonatal characteristics. The table shows significant differences in NMR by ANC booking visit, health care provider at the time of delivery, multiple birth, first birth and parity. Mothers who attended their first ANC visit in the first trimester of pregnancy, mothers with less than four children, and those delivered by a midwife or TBA were less likely to lose their babies within 28 days but mothers who attended their ANC booking visit in the second or third trimester, those delivered by a doctor, a relative or no one, and those with four or more children were more likely to lose their babies within 28 days of birth. Singleton babies and first births were significantly less likely than twins and subsequent births to die within 28 days of birth. There was no significant difference in the sex of the baby or day of birth by mortality.

Table 4.5.4: Summary of delivery and neonatal characteristics by neonatal mortality

	Total livebirths (n=21,647) n (%)	Dead (n=135) n (%)	NMR	P-value
ANC				
No	214	0	0	0.63*
Yes	9,942	50 (100)	5.0	
Missing	11,491	85		
Number of ANC				
0=No ANC	214 (2.1)	0	0.0	0.36
1	264 (2.6)	3 (6.0)	11.4	
2	456 (4.5)	5 (10.0)	11.1	
3	993 (9.8)	4 (8.0)	4.0	
4+	8,200 (81.0)	38 (76.0)	4.6	
Missing	11,520	85		
Booking visit				
0=No ANC	214 (2.1)	0	0	0.03
1-3 months	5,461 (53.9)	20 (40.0)	3.7	
3-6 months	3,976 (39.3)	27 (54.0)	6.8	
7+ months	478 (4.7)	3 (6.0)	6.3	
Missing	11,518	85		
Staff at delivery				
Doctor	791 (7.8)	11 (22.0)	13.9	<0.01
Midwife/Nurse	6,639 (65.3)	24 (48.0)	3.6	
TBA	1,803 (17.8)	8 (16.0)	4.4	
Relative	702 (6.9)	5 (10.0)	7.1	
Other	34 (0.3)	0	0	
No one	191 (1.9)	2 (4.0)	10.5	
Missing	11,487	85		
Sex				
Female	10,492 (48.5)	55 (40.7)	5.2	0.07
Male	11,155 (51.5)	80 (59.3)	7.2	
Twins				
No	20,717 (95.7)	106 (78.5)	5.1	<0.001
Yes	930 (4.3)	29 (21.5)	31.2	
First birth				
No	15,610 (72.1)	109 (80.7)	7.0	0.03
Yes	6,028 (27.9)	26 (19.3)	4.3	
Missing	9	0		
Parity				
1	1,844 (10.6)	7 (6.1)	3.8	<0.001
2	5,088 (29.2)	24 (20.9)	4.7	
3	3,879 (22.3)	18 (15.7)	4.6	
4+	6,602 (37.9)	66 (57.4)	10.0	
Missing	4,234	20		
Day of birth				
Weekday	15,726 (72.7)	95 (70.4)	6.0	0.55
Weekend	5,921 (27.4)	40 (29.6)	6.8	
Fishers exact				

4.5.3.3 Temporal trends in neonatal mortality rate in Dodowa

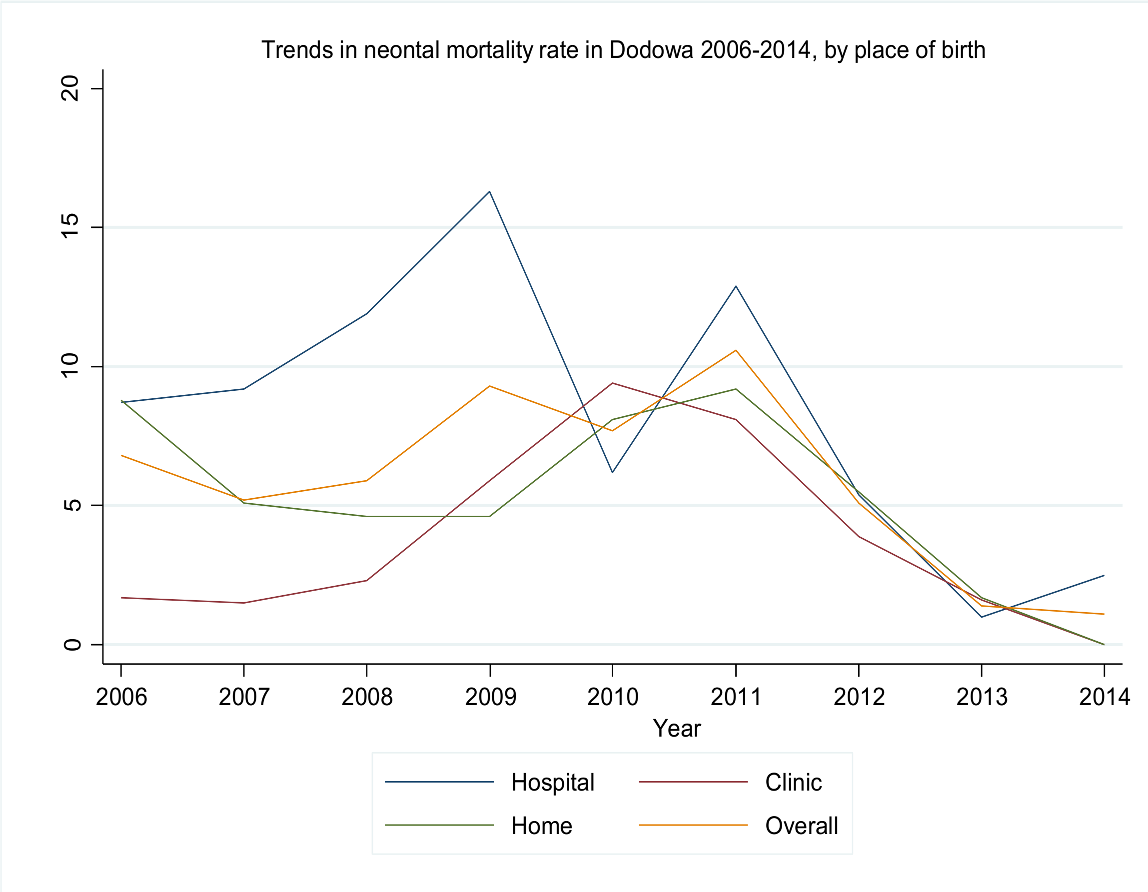


Figure 4.5.1: Temporal trends in neonatal mortality rate in Dodowa, 2006-2014

Figure 4.5.1 shows the temporal trends in neonatal mortality rate in Dodowa from 2006 to 2014. The graph shows that overall NMR in Dodowa dropped by 84% (from 6.8 per 1,000 in 2006 to 1.1 per 1,000 in 2014). Before 2011, the rate and pattern of decline in NMR was inconsistent, overall and by place of delivery, but after 2011, NMR dropped steeply to its lowest in 2014. Overall, NMR in Dodowa rose from 6.8 in 2006 to peak at 10.6 in 2011. From 2011, overall NMR dropped steeply to its lowest at 1.1 in 2014. In hospital, NMR increased from 8.7 in 2006 to its peak at 16.3 in 2009, then fell from 12.9 in 2011 to 2.5 in 2014. In clinics, NMR rose to a peak of 9.4 in 2010, and then fell to zero in 2014. Following an initial drop from 2006 to 2009, the NMR among home births rose to 9.2 in 2011 and then fell to zero in 2014.

Table 4.5.5 summarises the temporal trends in NMR. The table shows significant differences in NMR by year of birth, among all babies and those delivered in hospital. Babies delivered from 2012 onwards were more likely to live beyond the neonatal period, overall and among hospital births. Overall, babies delivered in 2006 and between 2009 and 2011 had higher NMR than the other previous years. In hospitals, those delivered from 2006-2009 were significantly more likely to die.

Table 4.5.5: Temporal trends in neonatal mortality rate in Dodowa

Year of birth	Total livebirths	Dead	NMR	p for trend
Overall				
2006	2,062	14	6.8	0.02
2007	2,479	13	5.2	
2008	2,729	16	5.9	
2009	2,463	23	9.3	
2010	2,739	21	7.7	
2011	3,117	33	10.6	
2012	1,972	10	5.1	
2013	2,215	3	1.4	
2014	1,871	2	1.1	
Hospital				
2006	460	4	8.7	<0.01
2007	650	6	9.2	
2008	758	9	11.9	
2009	921	15	16.3	
2010	1,135	7	6.2	
2011	1,396	18	12.9	
2012	920	5	5.4	
2013	998	1	1.0	
2014	798	2	2.5	
Clinic				
2006	584	1	1.7	0.85
2007	646	1	1.5	
2008	883	2	2.3	
2009	677	4	5.9	
2010	742	7	9.4	
2011	739	6	8.1	
2012	510	2	3.9	
2013	622	1	1.6	
2014	634	0	0.0	
Home				
2006	1,018	9	8.8	0.20
2007	1,183	6	5.1	
2008	1,088	5	4.6	
2009	865	4	4.6	
2010	862	7	8.1	
2011	982	9	9.2	
2012	542	3	5.5	
2013	595	1	1.7	
2014	439	0	0.0	

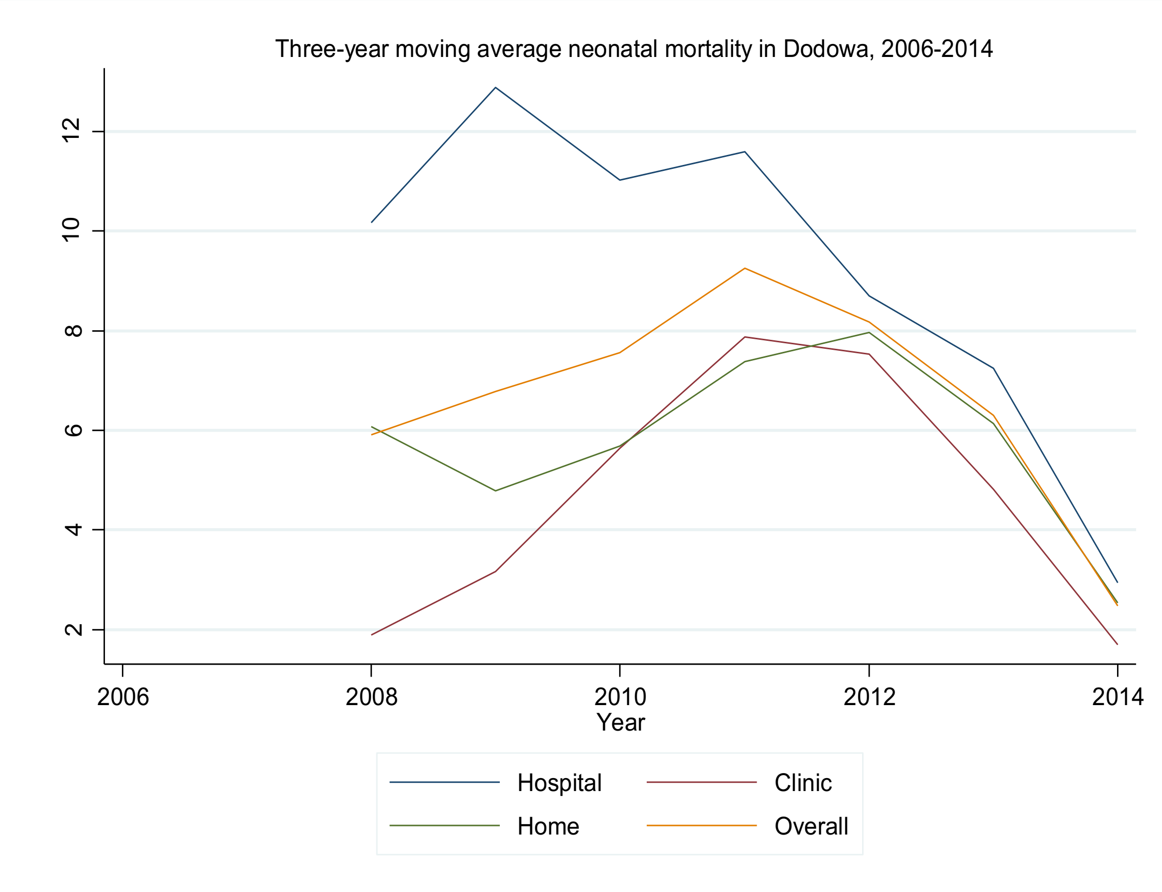


Fig 4.5.2: Three-year moving average neonatal mortality rate in Dodowa, 2006-2014

The line graph in Fig 4.5.2 shows a three-year moving average NMR in Dodowa from 2006 to 2014. The graph shows that the overall NMR in Dodowa was lower in 2014 than 2006. However, the trend of decline seemed parabolic, peaking in 2011. Hospital births consistently had the highest moving average NMR and clinic births had the lowest moving average NMR.

4.5.3.4 Factors associated with neonatal mortality in Dodowa

This section presents the results of univariate and multivariable logistic regression analyses of the associations between maternal, delivery and neonatal characteristics and neonatal mortality, overall and stratified by place of birth. The regression models were run both on complete cases (Tables 4.5.6-9) and the imputed data (Tables 4.5.10-13).

Overall births

Univariate analyses of the complete cases (Tables 4.5.6 and 4.5.7) suggested that twins were associated with a very high risk of neonatal death. Poor maternal socioeconomic status, cohabiting and first birth were associated with a lower risk of neonatal death. There was also a significant positive trend in risk of neonatal death by parity and education and the risk for neonatal death decreased over the study period. Compared to babies born at home, those born in hospital had a higher risk of death and those born in a clinic had a lower risk of death but the associations were not significant. Univariate analyses of the imputed data showed similar results (Tables 4.5.10 and 4.5.11).

After adjusting for potentially confounding variables, multivariable logistic regression of the complete cases (Tables 4.5.8 and 4.5.9) showed that being born in hospital, first birth, twins and Christianity were associated with an increased risk of neonatal death in Dodowa. The results also suggested a significant trend in the risk of neonatal death by education. The adjusted odds ratios for neonatal mortality increased with decreasing level of education. Compared to babies born in 2006, those born in 2013 and 2014 had a significantly lower risk of death and the mortality trend was statistically significant.

Multivariable logistic regression analyses of the imputed data (Tables 4.5.12 and 4.5.13) showed that compared to babies born at home, those born in hospital were 51% (adjusted OR 1.51, 95% CI 1.17-1.95, p<0.01) more likely to die in the neonatal period and those born in a clinic were 24% less likely to die (adjusted OR 0.76, 95% CI 0.67-0.87, p<0.001). Compared to singletons, twins were five times more likely to die in the neonatal period (adjusted OR 5.09, 95% CI 3.62-7.14, p<0.001). The risk of neonatal mortality decreased with increasing level of maternal education (p<0.001) and year of birth (p=0.01). Mothers who had attained at least secondary education were 59% less likely than those with basic education to lose babies in the neonatal period.

The area under the ROC curve was 78% (74%-82%) showing moderate strength of the overall multivariable logistic regression model. A Hosmer-Lemeshow test for the goodness of fit was not significant at varying degrees of freedom, indicating the adequacy of the model (X^2=12.13, df=10, p=0.28; X^2=8.47, df=12, p=0.75).

Hospital births

Univariate analyses of the complete (Tables 4.5.6 and 4.5.7) and imputed cases (Tables 4.5.10 and 4.5.11) showed that, among babies delivered in hospitals, sex, twins, and first birth were significant risk factors for neonatal mortality. Boys (OR 1.75, 95% CI 1.05-2.90, p=0.03) and twins (OR 5.35, 95% CI 3.09-9.25, p<0.001) had a higher risk of death and first births (OR 0.40, 95% CI 0.21-0.75, p<0.01) had a lower risk of death. When stratified by birth order, there was an increasing risk of neonatal mortality with increasing parity (p<0.01). In particular, the babies of mothers who had four or more children were at much greater risk of death (OR 3.68, 95% CI 1.30-10.43, p=0.01) compared to primiparous mothers. The results also showed a higher risk of neonatal mortality was associated with decreasing levels of maternal education (p=0.02).

Multivariable analyses of the complete cases (Tables 4.5.8 and 4.5.9) showed that among babies delivered in hospitals, boys (adjusted OR 1.96, 95% CI 1.12-3.43, p=0.02) and twins (adjusted OR 4.13, 95% CI 2.17-7.88, p<0.001) had a higher risk of death. Multivariable analyses of the imputed data (Tables 4.5.12 and 4.5.13) showed similar significant results. Maternal education which was found to be associated with neonatal mortality in the univariate model was not significant in the multivariable model for both complete and imputed data suggesting that the univariate results were confounded.

Clinic births

Univariate analyses of clinic births showed that twins, maternal age over 30 years, and being married were associated with high risk of neonatal death (Tables 4.5.6, 4.5.7, 4.5.10 and 4.5.11). The unadjusted risk of neonatal mortality increased with increasing parity and age. After adjusting for potentially confounding variables, twins remained at very high risk of neonatal death in both the complete cases (adjusted OR 4.99, 95% CI 1.60-15.58, p=0.01) and the imputed data (adjusted OR 4.49, 95% CI 1.34-14.95, p=0.01).

Home births

Univariate analyses of babies delivered at home showed that twin births were associated with neonatal death, for both complete (Table 4.5.7) and imputed data (Table 4.5.11). After adjusting for confounding variables, twins remained at a very high risk of death in both complete cases (adjusted OR 8.37, 95% CI 3.01-23.26, p<0.001) and imputed data (adjusted OR 7.05, 95% CI 2.77-17.95, p<0.001).

Table 4.5.6: Univariate logistic regression analyses of association between maternal characteristics and neonatal mortality in Dodowa (complete case analyses)

	Hospital		Clinic		Home		Overall		
	Univariate	p-value	Univariate	p-value	Univariate	p-value	Univariate	p-value	P for trend
	OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)		
Place of delivery									
Hospital							1.44 (0.98-2.11)	0.06	
Clinic							0.68 (0.41-1.12)	0.13	
Home							1.00		
Maternal age									
<20 years	0.34 (0.10-1.10)	0.07	1.61 (0.32-8.00)	0.56[1]	0.70 (0.26-1.90)	0.48	0.56 (0.28-1.13)	0.11	0.07
20-29	1.00		1.00		1.00		1.00		
30-39	0.89 (0.53-1.50)	0.65	3.35 (1.24-9.07)	0.02	1.08 (0.57-2.06)	0.82	1.19 (0.82-1.72)	0.37	
40+	0.84 (0.30-2.37)	0.74	9.16 (2.78-30.19)	<0.01	0.16 (0.01-2.56)	0.19	1.14 (0.57-2.28)	0.72	
Socioeconomic status									
Poor	0.56 (0.20-1.56)	0.27	0.08 (0.00-1.46)	0.09	0.38 (0.12-1.25)	0.11	0.40 (0.19-0.83)	0.01	0.29
Next poor	2.88 (1.41-5.90)	<0.01	1.48 (0.52-4.26)	0.46	0.80 (0.31-2.05)	0.64	1.61 (0.98-2.66)	0.06	
Average	1.76 (0.82-3.75)	0.15	0.68 (0.19-2.51	0.57	0.81 (0.31-2.12)	0.67	1.22 (0.72-2.07)	0.46	
Next rich	1.73 (0.84-3.58)	0.14	1.41 (0.51-3.92)	0.51	0.25 (0.06-0.99)	0.05	1.11 (0.65-1.91)	0.70	
Rich	1.00		1.00		1.00		1.00		
Education									
None	1.22 (0.71-2.11)	0.47[2]	1.79 (0.78-4.09)	0.17	1.19 (0.65-2.18)	0.57	1.21 (0.85-1.74)	0.29	0.03
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.23 (0.05-0.93)	0.04	0.74 (0.10-5.69)	0.78	1.08 (0.14-8.01)	0.94	0.41 (0.15-1.12)	0.08	
Ethnicity									
Ga-Dangbe	1.00		1.00		1.00		1.00		
Akan	0.34 (0.08-1.41)	0.14	0.37 (0.02-6.09)	0.49	2.27 (0.44-11.75)	0.33	0.45 (0.14-1.40)	0.17	
Ewe	0.49 (0.22-1.07)	0.07	0.17 (0.01-2.77)	0.21	0.92 (0.40-2.13)	0.84	0.58 (0.33-1.03)	0.06	
Northern	0.20 (0.03-1.47)	0.12	0.43 (0.03-7.07)	0.55	1.65 (0.45-5.98)	0.45	0.44 (0.14-1.38)	0.16	
Other	2.99 (0.71-12.50)	0.13	15.47 (4.02-59.62)	<0.001	1.80 (0.11-29.75)	0.68	3.95 (1.44-10.86)	0.01	
Religion									
Christianity	1.00		1.00		1.00		1.00		
Islam	0.88 (0.32-2.43)	0.81	1.13 (0.22-5.92)	0.88	0.88 (0.21-3.64)	0.86	0.89 (0.42-1.91)	0.77	
Traditional/other	1.60 (0.39-6.61)	0.52	0.68 (0.04-11.26)	0.79	0.83 (0.20-3.43)	0.79	0.87 (0.32-2.35)	0.78	
Marital status									
Single	1.35 (0.71-2.58)	0.36	0.17 (0.04-0.76)	0.02	1.02 (0.49-2.13)	0.95	0.91 (0.59-1.42)	0.68	
Married	1.00		1.00		1.00		1.00		
Previous married	0.73 (0.10-5.56)	0.76	0.91 (0.12-7.12)	0.93	2.51 (0.71-8.90)	0.16	1.37 (0.54-3.48)	0.51	
Cohabiting	1.04 (0.56-1.93)	0.89	0.46 (0.19-1.08)	0.08	0.38 (0.17-0.86)	0.02	0.63 (0.42-0.97)	0.03	

1 (p<0.001) 2 (p=0.02) 3 (p<0.01) 4 (p=0.01)

Table 4.5.7: Univariate logistic regression analyses of association between delivery characteristics and neonatal mortality in Dodowa (complete case analyses)

	Hospital		Clinic		Home		Overall		
	Univariate	**p-value**	**Univariate**	**p-value**	**Univariate**	**p-value**	**Univariate**	**p-value**	**P-trend**
	OR (95% CI)		**OR (95% CI)**		**OR (95% CI)**		**OR (95% CI)**		
Sex									
Female	1.00		1.00		1.00		1.00		
Male	1.75 (1.05-2.90)	0.03	0.69 (0.31-1.56)	0.38	1.37 (0.75-2.51)	0.30	1.37 (0.97-1.93)	0.07	
ANC									
Yes	0.28 (0.02-4.71)	0.38*	0.13 (0.01-2.38)	0.17*	1.88 (0.11-31.65)*	0.66	2.19 (0.13-35.61)	0.58*	
No	1.00		1.00		1.00		1.00		
Multiple birth									
No	1.00		1.00		1.00		1.00		
Yes	5.35 (3.09-9.25)	<0.001	6.20 (2.10-18.31)	<0.01	6.90 (3.04-15.66)	<0.001	6.26 (4.13-9.49)	<0.001	
First birth									
Yes	0.40 (0.21-0.75)	<0.01	0.25 (0.06-1.05)	0.06	1.41 (0.72-2.74)	0.31	0.62 (0.40-0.95)	0.03	
No	1.00		1.00		1.00		1.00		
Parity									
1	1.00		1.00		1.00		1.00		
2	1.37 (0.43-4.37)	0.60[1]	2.44 (0.13-47.37)	0.56*[3]	0.75 (0.21-2.72)	0.67	1.24 (0.53-2.89)	0.61	<0.001
3	2.08 (0.67-6.46)	0.21	4.05 (0.22-75.42)	0.35	0.19 (0.03-1.13)	0.07	1.22 (0.51-2.93)	0.65	
4+	3.68 (1.30-10.43)	0.01	9.25 (0.55-154.89)	0.12	0.85 (0.25-2.91)	0.80	2.65 (1.21-5.79)	0.01	
Year of birth									
2006	1.00		1.00		1.00		1.00		
2007	1.06 (0.30-3.79)	0.93	0.90 (0.06-14.48)	0.94	0.57 (0.20-1.61)	0.29	0.77 (0.36-1.64)	0.50	0.02
2008	1.37 (0.42-4.47)	0.60	1.32 (0.12-14.63)	0.82	0.52 (0.17-1.55)	0.24	0.86 (0.42-1.77)	0.69	
2009	1.89 (0.62-5.72)	0.26	3.47 (0.39-31.09)	0.27	0.52 (0.16-1.70)	0.28	1.38 (0.71-2.69)	0.35	
2010	0.71 (0.21-2.43)	0.58	5.55 (0.68-45.26)	0.11	0.92 (0.34-2.47)	0.87	1.13 (0.57-2.23)	0.72	
2011	1.49 (0.50-4.42)	0.47	4.77 (0.57-39.75)	0.15	1.04 (0.41-2.62)	0.94	1.57 (0.84-2.93)	0.16	
2012	0.62 (0.17-2.33)	0.48	2.30 (0.21-25.39)	0.50	0.62 (0.17-2.31)	0.48	0.75 (0.33-1.68)	0.48	
2013	0.11 (0.01-1.03)	0.05	0.94 (0.06-15.04)	0.96	0.19 (0.02-1.49)	0.11	0.20 (0.06-0.69)	0.01	
2104	0.29 (0.05-1.57)	0.15	Omitted	-	Omitted	-	0.16 (0.04-0.69)	0.01	
Day of birth									
Weekday	1.00		1.00		1.00		1.00		
Weekend	0.73 (0.41-1.33)	0.31	1.88 (0.83-4.24)	0.13	1.46 (0.79-2.70)	0.23	1.12 (0.77-1.62)	0.55	

1 (p<0.001) 2 (p=0.02) 3 (p<0.01) 4 (p=0.01)

Table 4.5.8: Multivariable logistic regression of association between maternal factors and neonatal mortality in Dodowa (complete cases analyses)

	Hospital (n=6,007)		Clinic* (n=4,819)		Home (n=5,315)		Overall (N=17,036)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	P for trend
Place of delivery									
Hospital							2.00 (1.46-2.73)	<0.001	
Clinic							0.97 (0.41-1.12)	0.68	
Home							1.00		
Maternal age									
<20 years	0.40 (0.08-2.12)	0.28	1.23 (0.04-34.94)	0.90	0.64 (0.12-3.46)	0.60	0.58 (0.36-0.94)	0.03	0.99
20-29	1.00		1.00		1.00		1.00		
30-39	0.75 (0.40-1.42)	0.38	1.78 (0.62-5.15)	0.29	0.96 (0.41-2.25)	0.92	1.01 (0.68-1.51)	0.95	
40+	0.58 (0.18-1.84)	0.35	2.91 (0.79-10.70)	0.11	-		0.81 (0.20-3.17)	0.76	
Socioeconomic status									
Poor	0.41 (0.13-1.31)	0.13	0.08 (0.01-1.38)	0.08	0.54 (0.11-2.62)	0.44	0.35 (0.15-0.83)	0.02	0.05
Next poor	1.39 (0.62-3.15)	0.43	0.64 (0.18-2.28)	0.49	0.94 (0.24-3.75)	0.94	1.06 (0.69-1.63)	0.80	
Average	1.16 (0.52-2.60)	0.71	0.39 (0.09-1.62)	0.20	1.36 (0.35-5.26)	0.66	1.06 (0.64-1.75)	0.81	
Next rich	1.19 (0.55-2.58)	0.65	1.00 (0.32-3.08)	1.00	0.55 (0.11-2.85)	0.48	1.04 (0.81-1.33)	0.76	
Rich	1.00		1.00		1.00		1.00		
Education									
None	1.03 (0.55-1.91)	0.94	1.17 (0.46-2.92)	0.74	1.41 (0.67-3.00)	0.37	1.18 (0.93-1.49)	0.15	<0.001
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.22 (0.03-1.66)	0.14	0.83 (0.10-6.70)	0.86	1.31 (0.16-10.51)	0.80	0.41 (0.15-1.10)	0.08	
Ethnicity									
Ga-Dangbe	1.00		1.00		1.00		1.00		
Akan	0.70 (0.16-3.01)	0.64	0.39 (0.02-6.85)	0.52	2.71 (0.33-22.19)	0.35	0.67 (0.25-1.79)	0.43	
Ewe	0.59 (0.25-1.39)	0.23	0.20 (0.01-3.44)	0.27	0.90 (0.33-2.47)	0.84	0.61 (0.36-1.03)	0.07	
Northern	0.33 (0.03-4.25)	0.39	0.72 (0.01-36.86)	0.87	3.41 (0.08-144.32)	0.52	0.84 (0.19-3.64)	0.81	
Other	4.11 (0.47-36.31)	0.20	18.62 (2.05-168.68)	0.01	-		8.24 (1.49-45.53)	0.02	
Religion									
Christianity	1.00		1.00		1.00		1.00		
Islam	0.73 (0.10-5.33)	0.76	0.83 (0.05-13.28)	0.89	0.26 (0.01-10.66)	0.48	0.43 (0.20-0.92)	0.03	
Traditional/other	1.51 (0.34-6.61)	0.59	0.46 (0.03-7.88)	0.59	1.33 (0.30-5.95)	0.71	0.79 (0.31-2.01)	0.62	
Marital status									
Single	2.08 (0.93-4.65)	0.07	0.32 (0.05-1.94)	0.22	0.83 (0.29-2.40)	0.74	1.21 (0.51-2.89)	0.67	
Married	1.00		1.00		1.00		1.00		
Previous married	1.06 (0.13-8.47)	0.96	1.69 (0.29-9.84)	0.56	2.20 (0.43-11.17)	0.34	1.38 (0.75-2.56)	0.30	

Cohabiting	1.06 (0.53-2.11)	0.87	0.60 (0.24-1.49)	0.27	0.39 (0.16-0.94)	0.04	0.71 (0.39-1.31)	0.28	
			*firthlogit						

Table 4.5.9: Multivariable logistic regression analyses of association between delivery characteristics and neonatal mortality in Dodowa (complete case analyses)

	Hospital (n=6,007)		Clinic* (n=4,819)		Home (n=5,315)		Overall (N=17,036)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	P for trend
Sex of newborn									
Female	1.00		1.00		1.00		1.00		
Male	1.96 (1.12-3.43)	0.02	1.11 (0.47-2.60)	0.81	1.36 (0.67-2.78)	0.40	1.51 (1.00-2.27)	0.05	
Multiple birth									
No	1.00		1.00		1.00		1.00		
Yes	4.13 (2.17-7.88)	<0.001	4.99 (1.60-15.58)	0.01	8.37 (3.01-23.26)	<0.001	5.39 (3.79-7.65)	<0.001	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.57 (0.15-2.11)	0.40	0.93 (0.03-27.88)	0.96	0.30 (0.06-1.44)	0.13	0.53 (0.39-0.71)	<0.001	0.07
3	0.75 (0.20-2.81)	0.67	0.91 (0.03-28.88)	0.96	0.06 (0.01-0.46)	0.01	0.42 (0.11-1.58)	0.20	
4+	1.19 (0.31-4.51)	0.80	1.25 (0.04-39.05)	0.90	0.30 (0.06-1.55)	0.15	0.81 (0.37-1.80)	0.61	
Year of birth									
2006	1.00		1.00		1.00		1.00		
2007	1.74 (0.33-9.30)	0.52	1.05 (0.11-10.40)	1.00	0.54 (0.17-1.70)	0.29	0.87 (0.38-2.00)	0.75	0.01
2008	2.19 (0.45-10.62)	0.33	0.67 (0.07-6.64)	0.74	0.35 (0.09-1.37)	0.13	0.81 (0.24-2.79)	0.74	
2009	2.71 (0.60-12.35)	0.20	2.13 (0.32-14.34)	0.44	0.37 (0.09-1.50)	0.17	1.32 (0.38-4.53)	0.66	
2010	1.13 (0.23-5.61)	0.88	3.61 (0.60-21.89)	0.16	0.28 (0.06-1.36)	0.11	0.91 (0.23-3.71)	0.90	
2011	1.69 (0.37-7.73)	0.50	2.72 (0.43-17.44)	0.29	0.94 (0.32-2.78)	0.92	1.25 (0.57-2.74)	0.57	
2012	0.77 (0.14-4.32)	0.77	1.63 (0.20-13.28)	0.65	0.27 (0.05-1.52)	0.14	0.52 (0.19-1.44)	0.21	
2013	0.13 (0.01-1.49)	0.10	0.68 (0.06-7.25)	0.75	0.14 (0.01-1.33)	0.09	0.14 (0.05-0.39)	<0.001	
2104	0.40 (0.05-3.08)	0.38	0.43 (0.02-11.50)	0.62	-		0.14 (0.02-0.89)	0.04	
Day of birth									
Weekday	1.00		1.00		1.00		1.00		
Weekend	0.66 (0.35-1.27)	0.21	2.02 (0.86-4.74)	0.10	1.48 (0.71-3.06)	0.29	1.09 (0.56-2.11)	0.80	
			*firthlogit						

Table 4.5.10: Univariate logistic regression analyses of association between maternal characteristics and neonatal mortality in Dodowa, using multiple imputations

	Hospital		Clinic		Home		Overall		
	Univariate OR (95% CI)	**p-value**	**Univariate OR (95% CI)**	**p-value**	**Univariate OR (95% CI)**	**p-value**	**Univariate OR (95% CI)**	**p-value**	**P for trend**
Place of delivery									
Hospital							1.44 (0.98-2.11)	0.06	0.04
Clinic							0.68 (0.41-1.12)	0.13	
Home							1.00		
Maternal age									
<20 years	0.34 (0.10-1.10)	0.07	1.61 (0.32-7.98)	0.56[3]	0.63 (0.22-1.82)	0.40	0.56 (0.28-1.13)	0.11	0.07
20-29	1.00		1.00		1.00		1.00		
30-39	0.89 (0.53-1.50)	0.65	3.35 (1.24-9.08)	0.02	1.06 (0.55-2.03)	0.86	1.19 (0.82-1.72)	0.37	
40+	0.84 (0.30-2.36)	0.74	9.16 (2.78-30.20)	<0.001	-		1.13 (0.56-2.28)	0.72	
Socioeconomic status									
Poor	0.56 (0.20-1.56)	0.27	-		0.38 (0.12-1.25)	0.11	0.40 (0.19-0.83)	0.01	0.29
Next poor	2.88 (1.41-5.90)	0.004	1.50 (0.50-4.48)	0.47	0.80 (0.31-2.05)	0.64	1.61 (0.98-2.66)	0.06	
Average	1.76 (0.82-3.75)	0.15	0.63 (0.16-2.54)	0.52	0.81 (0.31-2.12)	0.67	1.22 (0.72-2.07)	0.46	
Next rich	1.73 (0.84-3.58)	0.14	1.43 (0.50-4.15)	0.51	0.25 (0.06-0.99)	0.05	1.11 (0.65-1.91)	0.70	
Rich	1.00		1.00		1.00		1.00		
Education									
None	1.22 (0.71-2.11)	0.47[2]	1.79 (0.78-4.09)	0.17	1.19 (0.65-2.18)	0.57	1.21 (0.85-1.74)	0.29	0.03
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.23 (0.05-0.93)	0.04	0.74 (0.10-5.69)	0.78	1.08 (0.14-8.00)	0.94	0.41 (0.15-1.12)	0.08	
Ethnicity									
Ga-Dangbe	1.00				1.00		1.00		
Akan	0.34 (0.08-1.41)	0.14			1.54 (0.21-11.36)	0.67	0.45 (0.14-1.40)	0.17	0.18
Ewe	0.49 (0.22-1.07)	0.07			0.86 (0.36-2.05)	0.74	0.58 (0.33-1.03)	0.06	
Northern	0.20 (0.03-1.47)	0.12			1.34 (0.32-5.60)	0.69	0.44 (0.14-1.38)	0.16	
Other	2.99 (0.71-12.49)	0.13			-		3.95 (1.44-10.86)	0.01	
Religion									
Christianity	1.00		1.00		1.00		1.00		
Islam	0.88 (0.32-2.43)	0.81	0.77 (0.10-5.74)	0.80	0.88 (0.21-3.64)	0.86	0.89 (0.42-0.92)	0.77	0.70
Traditional/other	1.60 (0.39-6.61)	0.52	-	-	0.83 (0.20-3.43)	0.79	0.86 (0.32-2.35)	0.76	
Marital status									
Single	1.35 (0.71-2.57)	0.37	0.17 (0.04-0.76)	0.02	1.03 (0.49-2.14)	0.95	0.91 (0.59-1.42)	0.69	0.05
Married	1.00		1.00		1.00		1.00		
Previous married	0.73 (0.10-5.54)	0.76	0.91 (0.12-7.13)	0.93	2.47 (0.70-8.77)	0.16	1.36 (0.53-3.46)	0.52	
Cohabiting	1.04 (0.56-1.93)	0.90	0.46 (0.19-1.08)	0.08	0.40 (0.18-0.89)	0.03	0.64 (0.42-0.97)	0.04	

*firthlogit	1 (p<0.001)	2 (p=0.02)	3 (p<0.01)	4 (p=0.01)	5 (p=0.04)		

Table 4.5.11: Univariate logistic regression analyses of association between delivery characteristics and neonatal mortality in Dodowa, using multiple imputations

	Hospital		**Clinic**		**Home**		**Overall**		
	Univariate OR (95% CI)	**p-value**	**Univariate OR (95% CI)**	**p-value**	**Univariate OR (95% CI)**	**p-value**	**Univariate OR (95% CI)**	**p-value**	**P for trend**
Sex of newborn									
Female	1.00		1.00		1.00		1.00		
Male	1.75 (1.05-2.90)	0.03	0.69 (0.31-1.56)	0.38	1.37 (0.75-2.51)	0.30	1.37 (0.97-1.93)	0.07	
Multiple birth									
No	1.00		1.00		1.00		1.00		
Yes	5.35 (3.09-9.25)	<0.001	6.20 (2.10-18.31)	0.001	6.90 (3.04-15.66)	<0.001	6.26 (4.13-9.49)	<0.001	
First birth									
Yes	1.00		1.00		1.00		0.62 (0.40-0.95)	0.03	
No	0.40 (0.21-0.75)	<0.01	0.25 (0.06-1.05)	0.06	1.41 (0.72-2.74)	0.31	1.00		
Parity									
1	1.00		1.00		1.00		1.00		
2	1.48 (0.46-4.71)	0.51[1]	-		1.09 (0.30-3.92)	0.90	1.37 (0.59-3.15)	0.46	<0.001
3	2.12 (0.71-6.28)	0.18	-		0.42 (0.08-2.16)	0.30	1.32 (0.57-3.05)	0.51	
4+	3.96 (1.49-10.53)	0.01	-		1.25 (0.37-4.21)	0.72	2.83 (1.35-5.93)	0.01	
Year of birth									
2006	1.00		1.00		1.00		1.00		
2007	1.06 (0.30-3.79)	0.93	0.90 (0.06-14.48)	0.94	0.57 (0.20-1.61)	0.29	0.77 (0.36-1.64)	0.50	
2008	1.37 (0.42-4.47)	0.60	1.32 (0.12-14.63)	0.82	0.52 (0.17-1.55)	0.24	0.86 (0.42-1.77)	0.69	
2009	1.89 (0.622-5.72)	0.26	3.47 (0.39-31.09)	0.27	0.52 (0.16-1.70)	0.30	1.38 (0.71-2.69)	0.35	
2010	0.71 (0.21-2.43)	0.58	5.55 (0.68-45.26)	0.11	0.92 (0.34-2.47)	0.87	1.13 (0.57-2.23)	0.72	
2011	1.49 (0.50-4.42)	0.47	4.77 (0.57-39.75)	0.15	1.04 (0.41-2.62)	0.94	1.57 (0.84-2.93)	0.16	
2012	0.62 (0.17-2.33)	0.48	2.30 (0.21-25.39)	0.50	0.62 (0.17-2.31)	0.48	0.75 (0.33-1.68)	0.48	
2013	0.11 (0.01-1.03)	0.05	0.94 (0.06-15.04)	0.96	0.19 (0.02-1.49)	0.11	0.20 (0.06-0.69)	0.01	
2104	0.29 (0.05-1.57)	0.15	Omitted	-	Omitted		0.16 (0.04-0.69)	0.01	
Day of birth									
Weekday	1.00		1.00		1.00		1.00		
Weekend	0.73 (0.41-1.33)	0.31	1.88 (0.83-4.24)	0.13	1.46 (0.79-2.70)	0.23	1.12 (0.77-1.62)	0.55	
*firthlogit			1 (p<0.001)				2 (p=0.02)		

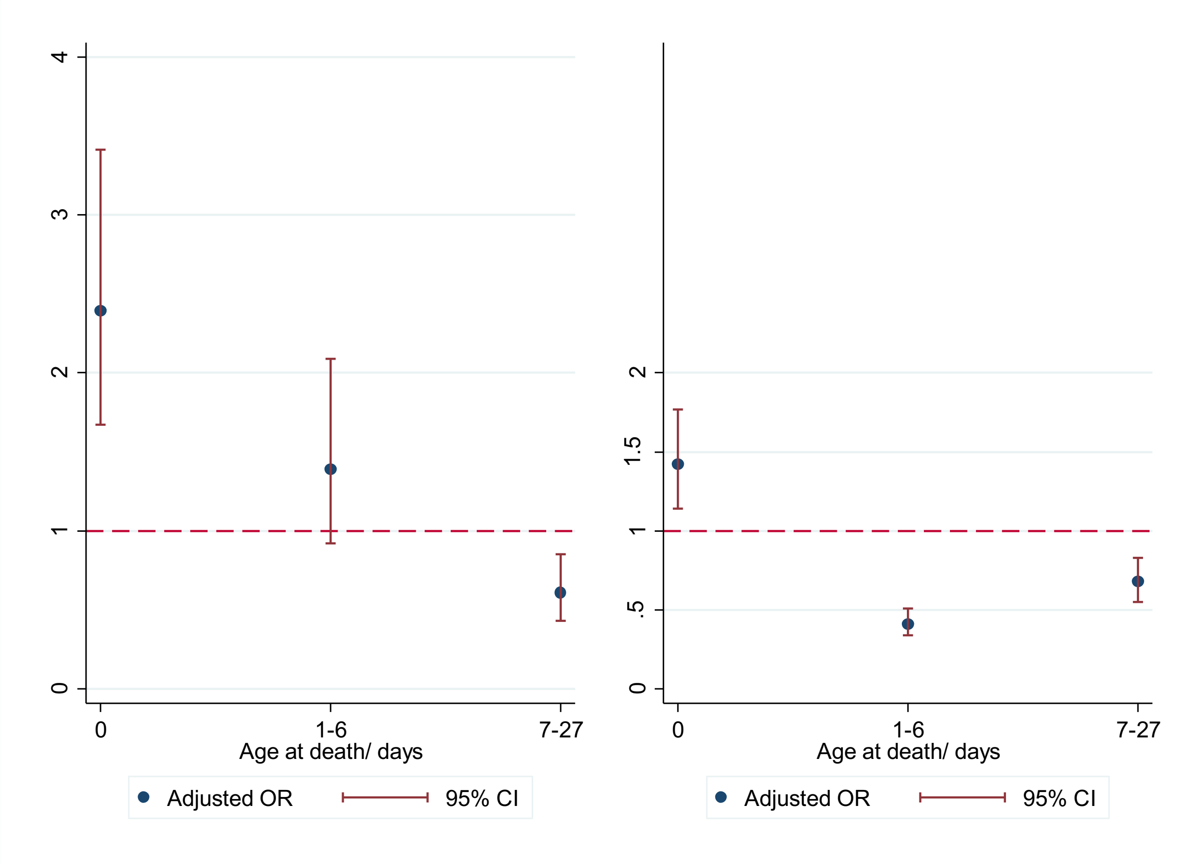
Table 4.5.12: Multivariable logistic regression of association between maternal demographics and neonatal mortality in Dodowa, using multiple imputations

	Hospital (n=8,036)		Clinic (n=3,396)		Home (n=6,622)		Overall (N=21,647)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	P for trend
Place of delivery									
Hospital							1.51 (1.17-1.95)	<0.01	
Clinic							0.76 (0.67-0.87)	<0.001	
Home							1.00		
Maternal age									
<20 years	0.24 (0.07-0.90)	0.03	3.56 (0.46-27.70)	0.23	0.38 (0.11-1.37)	0.14	0.48 (0.19-1.21)	0.12	0.63
20-29	1.00		1.00		1.00		1.00		
30-39	0.77 (0.42-1.44)	0.42	2.18 (0.70-6.73)	0.18	0.82 (0.37-1.81)	0.62	0.97 (0.67-1.42)	0.89	
40+	0.62 (0.20-1.97)	0.42	3.64 (0.91-14.52)	0.07	-	-	0.79 (0.19-3.31)	0.75	
Socioeconomic status									
Poor	0.52 (0.18-1.51)	0.23	-		0.33 (0.09-1.16)	0.08	0.38 (0.18-0.82)	0.01	0.05
Next poor	1.89 (0.88-4.05)	0.10	0.90 (0.26-3.12)	0.87	0.58 (0.21-1.62)	0.30	1.22 (0.60-2.48)	0.59	
Average	1.27 (0.58-2.79)	0.55	0.38 (0.08-1.71)	0.21	0.76 (0.28-2.08)	0.60	1.03 (0.62-1.70)	0.91	
Next rich	1.42 (0.67-2.99)	0.36	1.06 (0.33-3.38)	0.92	0.25 (0.06-1.04)	0.06	0.98 (0.47-2.06)	0.96	
Rich	1.00		1.00		1.00		1.00		
Education									
None	1.01 (0.56-1.83)	0.98	1.06 (0.42-2.66)	0.90	1.23 (0.64-2.36)	0.54	1.09 (0.93-1.28)	0.27	<0.001
Basic	1.00		1.00		1.00		1.00		
Secondary+	0.32 (0.07-1.37)	0.12	0.60 (0.05-6.98)	0.68	0.80 (0.10-6.15)	0.83	0.41 (0.24-0.68)	<0.01	
Ethnicity									
Ga-Dangbe	1.00		1.00		1.00		1.00		
Akan	0.64 (0.15-2.70)	0.54	-	-	1.60 (0.20-12.58)	0.66	0.59 (0.25-1.43)	0.24	
Ewe	0.58 (0.26-1.29)	0.18	-	-	0.82 (0.34-2.01)	0.67	0.59 (0.37-0.95)	0.03	
Northern	0.15 (0.01-1.69)	0.13	-	-	4.08 (0.12-143.05)	0.44	0.54 (0.07-4.02)	0.55	
Other	2.40 (0.34-16.93)	0.38	-	-	-		5.18 (0.86-31.17)	0.07	
Religion									
Christianity	1.00		1.00		1.00		1.00		
Islam	1.68 (0.36-7.82)	0.57	0.51 (0.03-8.74)	0.64	0.22 (0.01-7.48)	0.40	0.68 (0.16-2.80)	0.59	
Traditional/other	1.61 (0.37-6.97)	0.66	-		0.94 (0.22-4.07)	0.93	0.72 (0.28-1.85)	0.50	
Marital status									
Single	1.58 (0.75-3.32)	0.23	0.22 (0.04-1.24)	0.09	1.23 (0.51-2.96)	0.64	1.18 (0.63-2.18)	0.61	
Married	1.00		1.00		1.00		1.00		
Previous married	0.74 (0.09-5.81)	0.77	1.26 (0.15-10.44)	0.83	3.16 (0.82-12.23)	0.10	1.44 (0.55-3.76)	0.45	

Cohabiting	0.89 (0.46-1.72)	0.73	0.58 (0.23-1.48)	0.25	0.42 (0.18-0.98)	0.04	0.66 (0.41-1.06)	0.08	

Table 4.5.13: Multivariable logistic regression analyses of association between delivery characteristics and neonatal mortality in Dodowa, using multiple imputations

	Hospital (n=8,036)		Clinic (n=3,396)		Home (n=6,622)		Overall (N=21,647)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	P for trend
Sex									
Female	1.00		1.00		1.00		1.00		
Male	1.82 (1.09-3.05)	0.02	0.88 (0.38-2.07)	0.78	1.29 (0.70-2.39)	0.41	1.38 (0.91-2.10)	0.13	
Multiple birth									
No	1.00		1.00		1.00		1.00		
Yes	4.26 (2.28-7.94)	<0.001	4.49 (1.34-14.95)	0.01	7.05 (2.77-17.95)	<0.001	5.09 (3.62-7.14)	<0.001	
Parity									
1	1.00		1.00		1.00		1.00		
2	0.91 (0.26-3.19)	0.89	-	-	0.63 (0.14-2.86)	0.55	0.95 (0.46-1.96)	0.90	0.07
3	1.08 (0.32-3.64)	0.90	-	-	0.19 (0.03-1.23)	0.08	0.71 (0.22-2.25)	0.56	
4+	1.85 (0.55-6.21)	0.32	-	-	0.69 (0.14-3.45)	0.65	1.42 (0.61-3.31)	0.41	
Year of birth									
2006	1.00		1.00		1.00		1.00		
2007	1.23 (0.34-4.49)	0.75	1.11 (0.07-18.37)	0.94	0.56 (0.19-1.60)	0.28	0.85 (0.46-1.59)	0.61	0.01
2008	1.33 (0.39-4.48)	0.65	1.32 (0.12-15.04)	0.82	0.50 (0.16-1.54)	0.23	0.86 (0.43-1.72)	0.66	
2009	1.92 (0.61-6.00)	0.26	2.93 (0.31-27.84)	0.35	0.44 (0.13-1.47)	0.18	1.28 (0.48-3.42)	0.63	
2010	0.70 (0.20-2.46)	0.58	5.34 (0.63-45.55)	0.13	0.80 (0.29-2.26)	0.68	1.03 (0.41-2.57)	0.95	
2011	1.59 (0.52-4.88)	0.42	4.60 (0.52-40.31)	0.17	0.87 (0.32-2.38)	0.79	1.45 (0.73-2.88)	0.29	
2012	0.77 (0.20-3.04)	0.71	2.11 (0.18-25.08)	0.55	0.47 (0.11-1.95)	0.30	0.74 (0.41-1.33)	0.31	
2013	0.12 (0.13-1.15)	0.07	0.72 (0.04-12.83)	0.83	0.17 (0.02-1.47)	0.11	0.18 (0.08-0.44)	<0.001	
2104	0.39 (0.07-2.26)	0.30	-		-		0.18 (0.03-0.98)	0.05	
Day of birth									
Weekday	1.00		1.00		1.00		1.00		
Weekend	0.69 (0.38-1.26)	0.23	2.10 (0.90-4.91)	0.09	1.48 (0.79-2.77)	0.22	1.12 (0.61-2.05)	0.72	



Left- Hospital births, Right- Clinic births, Reference line- Home births

Fig 4.5.3: Forest plot of adjusted* odds ratio for the association between place of birth and neonatal mortality, according to age at death.

Figure 4.5.3 depicts a forest plot of the association between place of birth and neonatal mortality, according to the age of baby at the time of death. The graph shows that the risk of death among babies born in hospital or a clinic decreased with the baby's age. Compared to babies born at home, those born in hospital (left) had a significantly higher risk of death on the day of birth, but a significantly lower risk of death after the first week. There was no difference in the risk of death over 1-6 days between hospital and home births. Compared to home births, babies born in a clinic (right) had a higher risk of death on the day of birth but a significantly lower risk of death thereafter.

4.5.4 Neonatal deaths in Dodowa

This section summarises the results for neonatal deaths in the Dodowa HDSS over 2006-2014, only. Overall, 135 babies, representing 0.6% of the total livebirths in Dodowa, died within 28 days. The vast majority (83.7%) of these deaths occurred in the first week of birth and the rest died in the late neonatal period (16.3%).

This represents early and late neonatal mortality rates of 5.2 and 1.0 respectively.

4.5.4.1 Age at death

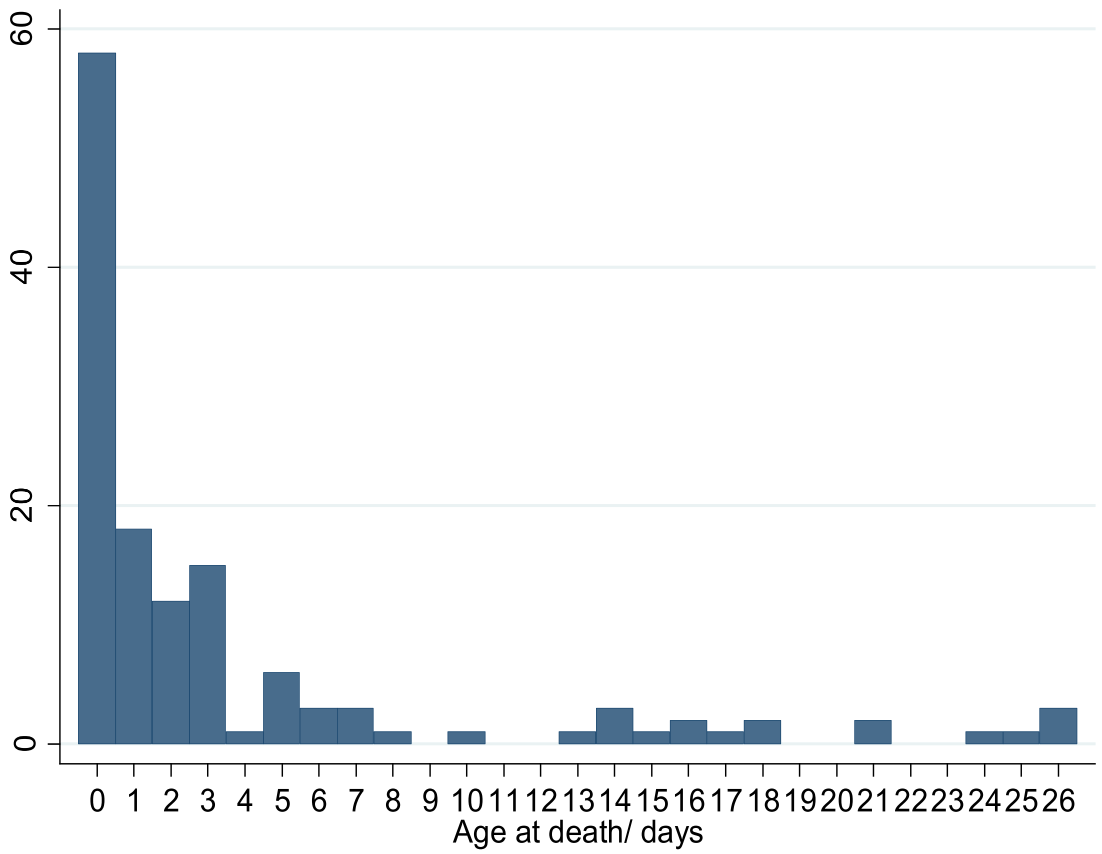


Fig 4.5.4: Distribution of neonatal deaths by age at death

The bar graph in Fig 4.5.4 depicts the number of neonatal deaths in Dodowa by the age at death. More neonatal deaths occurred on the day of birth (*n*=58, 43%), than on any other day, with few deaths after the first week.

4.5.4.2 Place of birth and death among neonatal deaths

Table 4.5.14 shows the distribution of neonatal deaths according to where the baby was born and where the baby died. The table shows statistically significant differences among neonatal deaths by place of birth. The vast majority of babies who were born in hospital died in hospital (82.1%) and the vast majority of those born at home also died at home (86.4%). There were more babies who were born in hospital but died at home (n=12, 17.9%) than home births that died in hospital (n=6, 13.6%), especially for those who died after the day of birth. There were also more clinic births that died at home (n=9, 37.5%) but no baby born at home died in a clinic, especially for deaths after the day of birth. After excluding babies who did not die in the same type of facility as they were born, a multivariable logistic regression showed that compared to babies who were born at home, those who were born in a hospital were more likely to die in a hospital (adjusted OR 1.58 95% CI 1.41-1.78) and those who were born in a clinic were less likely to die in a clinic (adjusted OR 0.23 95% CI 0.22-0.24).

Table 4.5.14: Distribution of neonatal deaths by place of birth and place of death

	Place of birth				
Place of death	**Hospital (n=67)**	**Clinic (n=24)**	**Home (n=44)**	**Total (N=135)**	**p-value**
All deaths (n=135)					
Hospital	55 (82.1)	5 (20.8)	6 (13.6)	66 (48.9)	<0.001
Clinic	0	6 (25.0)	0	6 (4.4)	
Home	12 (17.9)	9 (37.5)	38 (86.4)	59 (43.7)	
Other	0	4 (16.7)	0	4 (3.0)	
Day 0 (n=58)					
Hospital	30 (93.8)	2 (15.4)	1 (7.7)	33 (56.9)	<0.001
Clinic	0	5 (38.5)	0	5 (8.6)	
Home	2 (6.3)	3 (23.1)	12 (92.3)	17 (29.3)	
Other	0	3 (23.1)	0	3 (5.2)	
Days 1-6 (n=55)					
Hospital	22 (73.3)	1 (16.7)	5 (26.3)	28 (50.9)	<0.001
Clinic	0	1 (16.7)	0	1 (1.8)	
Home	8 (26.7)	3 (50.0)	14 (73.7)	25 (45.5)	
Other	0	1 (16.7)	0	1 (1.8)	
Days 7-27 (n=22)					
Hospital	3 (60.0)	2 (40.0)	0	5 (22.7)	0.02
Clinic	0	0	0	0	
Home	2 (40.0)	3 (60.0)	12 (100)	17 (77.3)	
Other	0	0	0	0	

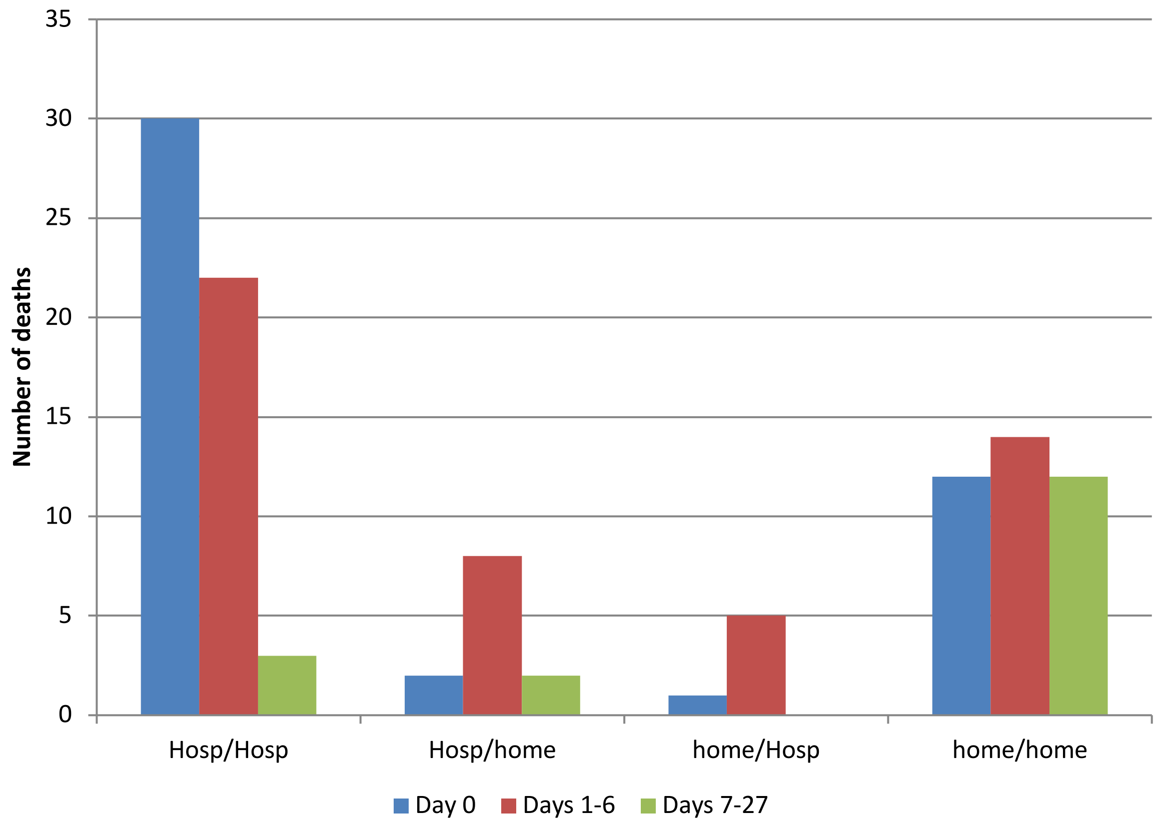


Fig 4.5.6: Age at death by place of birth and place of death

The bar graph in Fig 4.5.6 depicts the number of neonatal deaths according to where the baby was born and where they died (born/died), by the age at death. The graph shows that more than half of those who were born in hospital and died in hospital (hosp/hosp) died on the day of birth whereas two-thirds of those who were born in hospital but died at home (hosp/home) died over 1-6 days. No baby who was born at home but died in hospital died after the first week.

4.5.4.3 Age at death by place of birth, stratified by place of death

Table 4.5.15 shows the distribution of neonatal deaths by age of the baby at the time of death. The table shows that, overall, babies who were born in a clinic were more likely to die on the day of birth, those born in hospital were more likely to die over 1-6 days and those born at home were more likely to die after the first week. All the babies who died in a clinic (n=6) were born in a clinic, and all but one died on the day of birth.

Table 4.5.15: Distribution of neonatal deaths by place of birth and age at death

	Place of birth				
Place of death	**Hospital (n=67)**	**Clinic (n=24)**	**Home (n=44)**	**Total (N=135)**	**p-value**
All deaths (n=135)					
0	32 (47.8)	13 (54.2)	13 (29.6)	58 (43.0)	0.02
1-6	30 (44.8)	6 (25.0)	19 (43.2)	55 (40.7)	
7-27	5 (7.5)	5 (20.8)	12 (27.3)	22 (16.3)	
Hospital deaths (n=66)					
0	30 (54.6)	2 (40.0)	1 (16.7)	33 (50.0)	0.18
1-6	22 (40.0)	1 (20.0)	5 (83.3)	28 (42.4)	
7-27	3 (5.5)	2 (40.0)	0	5 (7.6)	
Home deaths (n=59)					
0	2 (16.7)	3 (33.3)	12 (31.6)	17 (28.8)	1.00
1-6	8 (66.7)	3 (33.3)	14 (36.8)	25 (42.4)	
7-27	2 (16.7)	3 (33.3)	12 (31.6)	17 (28.8)	
	Place of death				
	Hospital (n=66)	**Clinic (n=6)**	**Home (n=59)**	**Total**	
Day of death					
0	33 (50.0)	5 (83.3)	17 (28.8)	55 (42.0)	<0.001
0-6	28 (42.4)	1 (16.7)	25 (42.4)	54 (41.2)	
7-27	5 (7.6)	0	17 (28.8)	22 (16.8)	

Table 4.5.16: Distribution of neonatal deaths by age at death

	Day of death			
	0-6 days	**7-27 days**	**Total**	**P value**
Socioeconomic status				
Poor	8 (7.1)	2 (9.1)	10 (7.4)	0.07
Next poor	32 (28.3)	9 (40.9)	41 (30.4)	
Average	24 (21.2)	7 (31.8)	31 (23.0)	
Next rich	26 (23.0)	2 (9.1)	28 (20.7)	
Rich	23 (20.4)	2 (9.1)	25 (18.5)	
Education				
None	38 (33.6)	9 (40.9)	47 (34.8)	0.41
Basic	71 (62.8)	13 (59.1)	84 (62.2)	
Secondary+	4 (3.5)	0	4 (3.0)	
Care sought outside home				
Yes	56 (78.9)	8 (61.5)	64 (76.2)	0.29
No	15 (21.1)	5 (38.5)	20 (23.8)	
Missing	42	9	51	
Gestation				
7 months	7 (9.0)	1 (7.7)	8 (8.8)	0.52
8 months	4 (5.1)	0	4 (4.4)	
9 months	58 (74.4)	10 (76.9)	68 (74.7)	
10+ months	9 (11.5)	2 (15.4)	11 (12.1)	
Missing	35	9	44	

4.5.5 Summary

The results showed that the NMR in the Dodowa HDSS from 2016-2014 was 6.2. Babies born in hospital had the highest NMR of 8. The overall NMR in Dodowa reduced by 84% by the end of the study period. Compared to babies born at home, those born in hospital were more likely to die on the day of birth but less likely to die after the first week. Babies born in clinic were more likely than babies born at home to die on the day of birth, but less likely to die after the first day. Overall, twins were more likely than singletons, mothers who had at least secondary education were less likely than those with basic education, and poor mothers were less likely than rich mothers to die in the neonatal period. The risk of neonatal mortality decreased with maternal education and year of birth. When stratified by place of birth, twins were more likely than singletons to die in all delivery places, but twins born at home had the highest absolute risk of death and those born in hospital had the lowest. Among babies born in hospital only, boys were also more likely than girls to die in the neonatal period.

The profile for neonatal deaths showed that the vast majority of babies died in the first week, representing an early NMR of 5.2 and a late NMR of 1.0. There was an excess mortality among babies who were born in hospital but died at home, especially among babies who died after the first day.

4.6 Comparing neonatal mortality from three HDSS in Ghana

4.6.1 Introduction

This section compares NMRs, trends and causes of death between the three HDSS in Ghana.

4.6.2 Methods

The data from these three HDSS were combined and descriptive statistics were used to summarise the explanatory variables by place of delivery and NMR. These descriptive statistics are only meant to give a sense of how the measured variables compare between the three regions, rather than drawing any inferences. It was not possible to run logistic regression models on the combined dataset because of the following methodological issues:

1. Variables collected: There were significant differences in the variables collected in each research centre (See Table 4.2.1). This means that a logistic regression analysis on a combined dataset would exclude many important variables, for example maternal education, and thus the results will be heavily confounded.
2. Measurement of variables: There were some differences between how variables which were common to all research centres were measured. Socioeconomic status, for example, was based on quintile within each surveillance area. Therefore, a mother who was classified average in Dodowa may be equivalent to one classified rich in Navrongo.
3. Time periods: The data from the three regions covered different time periods, overlapping only from 2006-2010. A combined dataset for this period will therefore contain just a little over 30,000 live births.
4. Non representative: Although these data come from three geographically diverse areas in Ghana, a combined dataset is not representative of the whole of Ghana.
5. Value of the combined analyses: Finally, I do not think combining the data from the three regions would yield any additional substantial results beyond those from the regional analyses in sections 4.3-4.6. I suspect that the risk factors for neonatal mortality will be similar to those from the individual regions- hospital delivery, twins, boys, primiparity, low maternal education and ANC non-attendance.

4.6.3 Results

Altogether, 49,870 live births were delivered in the three HDSS within the study period. The majority (59.2%) of these babies were born in a health facility [(Hospital=18,976 (38.1%); Clinic=10,535 (21.1%)] and the rest were born at home (n=20,359, 40.8%). Table 4.6.1 shows statistically significant differences between the maternal and neonatal characteristics and place of birth. The table suggests that babies who died in the neonatal period and twins were more likely to be born in hospital. Older mothers, mothers who were classified as poor in each HDSS and those with at least four children were more likely to be delivered at home. Babies born in Navrongo were more likely to be born in hospital, those delivered in Dodowa were more likely to be born in clinic and those delivered in Kintampo were more likely to be born at home.

Table 4.6.1: Summary of maternal and neonatal characteristics in Ghana by place of delivery

	Hospital (n=18,976) n (%)	Clinic (n=10,535) n (%)	Home (n=20,359) n (%)	Total (N=49,870) n (%)	p-value
Neonatal mortality					
Alive	18,695 (98.5)	10,462 (99.3)	20,118 (98.8)	49,275 (98.8)	<0.001
Dead	281 (1.5)	73 (0.7)	241 (1.2)	595 (1.2)	
Maternal age					
<20 years	2,109 (11.1)	1,172 (11.2)	2,134 (10.5)	5,415 (10.9)	<0.001
20-29	9,534 (50.3)	5,543 (52.8)	9,800 (48.2)	24,877 (50.0)	
30-39	6,141 (32.4)	3,153 (30.0)	6,489 (31.9)	15,783 (31.7)	
40+	1,164 (6.1)	633 (6.0)	1,906 (9.4)	3,703 (7.4)	
Missing	28	34	30	92	
Socioeconomic status					
Poor	2,890 (15.7)	2,257 (21.8)	4,802 (24.0)	9,949 (20.4)	<0.001
Next poor	2,514 (13.7)	1,935 (18.7)	4,981 (24.9)	9,430 (19.4)	
Average	3,041 (16.5)	1,896 (18.3)	4,525 (22.7)	9,462 (19.4)	
Next rich	4,075 (22.2)	2,150 (20.8)	3,810 (19.1)	10,035 (20.6)	
Rich	5,875 (31.9)	2,112 (20.4)	1,858 (9.3)	9,845 (20.2)	
Missing	581	185	383	1,149	
Sex					
Female	9,119 (48.1)	5,155 (48.9)	10,148 (49.9)	24,422 (49.0)	<0.01
Male	9,857 (51.9)	5,380 (51.1)	10,211 (50.2)	25,448 (51.0)	
Parity					
1	4,673 (27.7)	1,769 (19.0)	2,682 (14.1)	9,124 (20.2)	<0.001
2	4,156 (24.6)	2,371 (25.4)	4,072 (21.5)	10,599 (23.5)	
3	3,154 (18.7)	1,974 (21.2)	3,586 (18.9)	8,714 (19.3)	
4+	4,910 (29.1)	3,212 (34.4)	8,640 (45.5)	16,762 (37.1)	
Missing	2,083	1,209	1,379	4,671	
Multiple birth					
Single	17,896 (94.6)	10,183 (97.0)	19,692 (96.9)	47,771 (96.1)	<0.001
Multiple	1,027 (5.4)	317 (3.0)	623 (3.1)	1,967 (4.0)	
Missing	53	35	44	132	
Day of birth					
Weekday	13,660 (72.0)	7,706 (73.2)	14,524 (71.3)	35,890 (72.0)	<0.01
Weekend	5,316 (28.0)	2,829 (26.9)	5,835 (28.7)	13,980 (28.0)	
Region					
Navrongo	7,306 (38.5)	2,708 (25.7)	7,002 (34.4)	17,016 (34.1)	<0.001
Kintampo	3,634 (19.2)	1,790 (17.0)	5,783 (28.4)	11,207 (22.5)	
Dodowa	8,036 (42.4)	6,037 (57.3)	7,574 (37.2)	21,647 (43.4)	

Table 4.6.2 shows the distribution of maternal and neonatal characteristics by deaths and NMR. Overall, the NMR in the three HDSS (2004-2014) was 11.9, representing NMR of 18.8 in Navrongo, 12.5 in Kintampo and 6.2 in Dodowa. After excluding births which did not occur in the period which overlaps between all the three regions, the NMR in the three HDSS from 2006-2010 was not significantly different (NMR=12.2). With the exception of socioeconomic status, maternal age and parity, there were significant differences in neonatal deaths according to the recorded explanatory variables. Babies born in hospital, boys and those born in Navrongo had the highest NMR compared to those born in clinic or at home, girls and those delivered in the Kintampo or Dodowa

respectively. Twins had a very high NMR compared to singletons, and the difference was statistically significant.

Table 4.6.2: Summary of maternal and neonatal characteristics in Ghana by neonatal deaths and NMR

	Total livebirths n (%)	Dead n (%)	NMR	p-value
All	49,870	595	11.9	-
Place of birth				
Hospital	18,976 (38.1)	281 (47.2)	14.8	<0.001
Clinic	10,535 (21.1)	73 (12.3)	6.9	
Home	20,359 (40.8)	241 (40.5)	11.8	
Maternal age				
<20 years	5,415 (10.9)	69 (11.6)	12.7	0.10
20-29	24,877 (50.0)	265 (44.6)	10.7	
30-39	15,783 (31.7)	208 (35.0)	13.2	
40+	3,703 (7.4)	52 (8.8)	14.0	
Missing	92	1		
Socioeconomic status				
Poor	9,949 (20.4)	95 (18.7)	9.5	0.81
Next poor	9,430 (19.4)	110 (21.6)	11.7	
Average	9,462 (19.4)	92 (18.1)	9.7	
Next rich	10,035 (20.6)	112 (22.0)	11.2	
Rich	9,845 (20.2)	100 (19.7)	10.2	
Missing	1,149	86		
Sex				
Female	24,422 (49.0)	254 (42.7)	10.4	<0.01
Male	25,448 (51.0)	341 (57.3)	13.4	
Parity				
1	9,124 (20.2)	155 (27.4)	17.0	0.34
2	10,599 (23.5)	90 (15.9)	8.5	
3	8,714 (19.3)	97 (17.2)	11.1	
4+	16,762 (37.1)	223 (39.5)	13.3	
Missing	4,671	30		
Multiple birth				
Single	47,771 (96.1)	508 (85.5)	10.6	<0.001
Multiple	1,967 (4.0)	86 (14.5)	43.7	
Missing	132	1		
Day of birth				
Weekday	35,890 (72.0)	406 (68.2)	11.3	0.04
Weekend	13,980 (28.0)	189 (31.8)	13.5	
Region				
Navrongo	17,016 (34.1)	320 (53.8)	18.8	<0.001
Kintampo	11,207 (22.5)	140 (23.5)	12.5	
Dodowa	21,647 (43.4)	135 (22.7)	6.2	

4.6.3.1 Temporal trends in NMRs by place of birth, 2006-2010

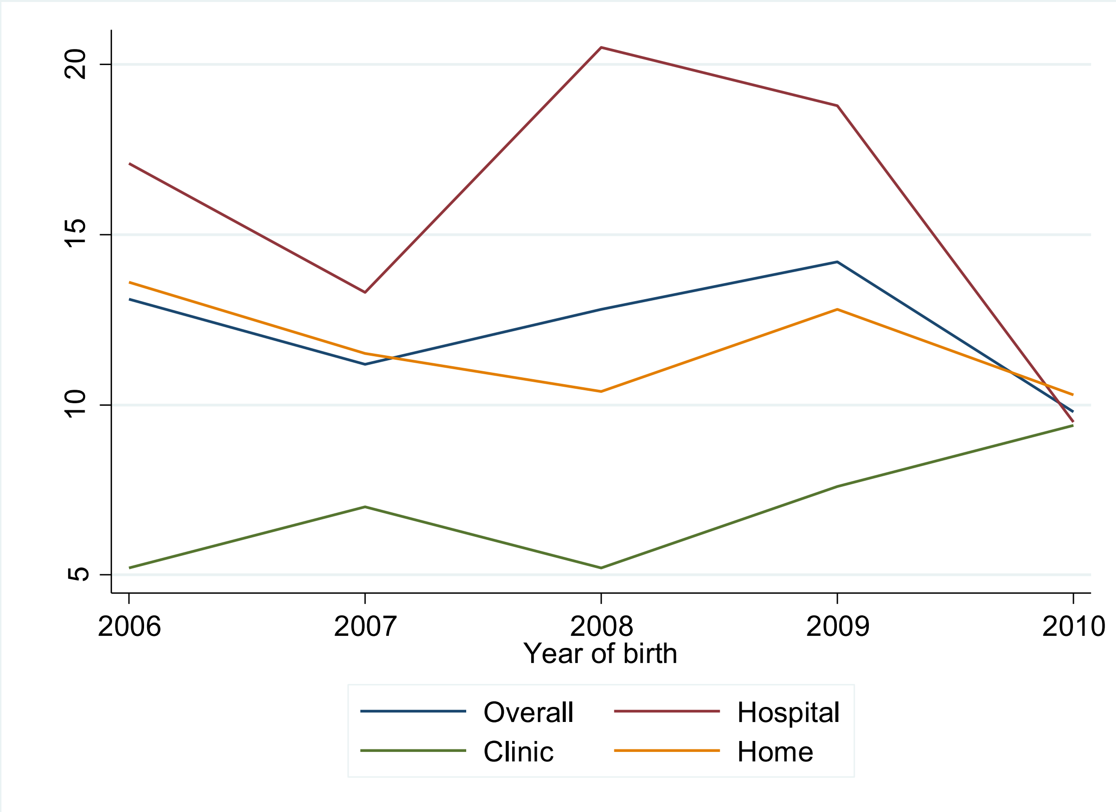


Fig 4.6.1: Temporal trends in neonatal mortality rate in Ghana 2006-2010, by place of birth

The line graph in Fig 4.6.1 shows the temporal trends in NMR in the three HDSS by place of birth for the period for which data were available in all the three HDSS. The graph shows that babies born in hospital had consistently higher NMR and clinic births had the least NMR from 2006-2009, but the NMRs in all the three delivery sites converged around 10 in 2010.

Table 4.6.3 shows the temporal trends in NMR in Ghana according to where the baby was born from 2006-2010. The table shows that NMR in Ghana reduced significantly over the study period, especially among babies born in hospital and those delivered at home.

Table 4.6.3: Temporal trends in neonatal mortality and NMR, 2006-2010

Year*	Total livebirths	Dead	NMR
Overall			
2006	5,578	73	13.1
2007	6,350	71	11.2
2008	6,556	84	12.8
2009	6,474	92	14.2
2010	6,769	66	9.8
Hospital			
2006	1,518	26	17.1
2007	1,886	25	13.3
2008	2,243	46	20.5
2009	2,660	50	18.8
2010	2,850	27	9.5
Clinic			
2006	963	5	5.2
2007	1,151	8	7.0
2008	1,346	7	5.2
2009	1,314	10	7.6
2010	1,593	15	9.4
Home			
2006	3,097	42	13.6
2007	3,313	38	11.5
2008	2,967	31	10.4
2009	2,500	32	12.8
2010	2,326	24	10.3
Table covers period for which data are available from all three HDSS			

Table 4.6.4 shows the NMRs in the three HDSS by place of delivery, for the period for which data were available in all three HDSSs. The table shows that hospital births had the highest NMR (15.6) and clinic births had the lowest (7.1). Overall, NMR was highest in Navrongo, followed by Kintampo and then Dodowa. When stratified by place of delivery, it appears the differences in NMR between Navrongo and Kintampo were more pronounced for home deliveries.

Table 4.6.4: NMR by region, 2006-2010

Place of birth	Total livebirths	Dead	NMR
Overall			
Hospital	11,157	174	15.6
Clinic	6,367	45	7.1
Home	14,203	167	11.8
Overall			
Navrongo	9,314	175	18.8
Kintampo	9,941	124	12.5
Dodowa	12,472	87	7.0
Hospital			
Navrongo	3,952	76	19.2
Kintampo	3,281	57	17.4
Dodowa	3,924	41	10.4
Clinic			
Navrongo	1,186	14	11.8
Kintampo	1,649	16	9.7
Dodowa	3,532	15	4.2
Home			
Navrongo	4,176	85	20.4
Kintampo	5,011	51	10.2
Dodowa	5,016	31	6.2
Table covers period for which data are available from all three HDSS			

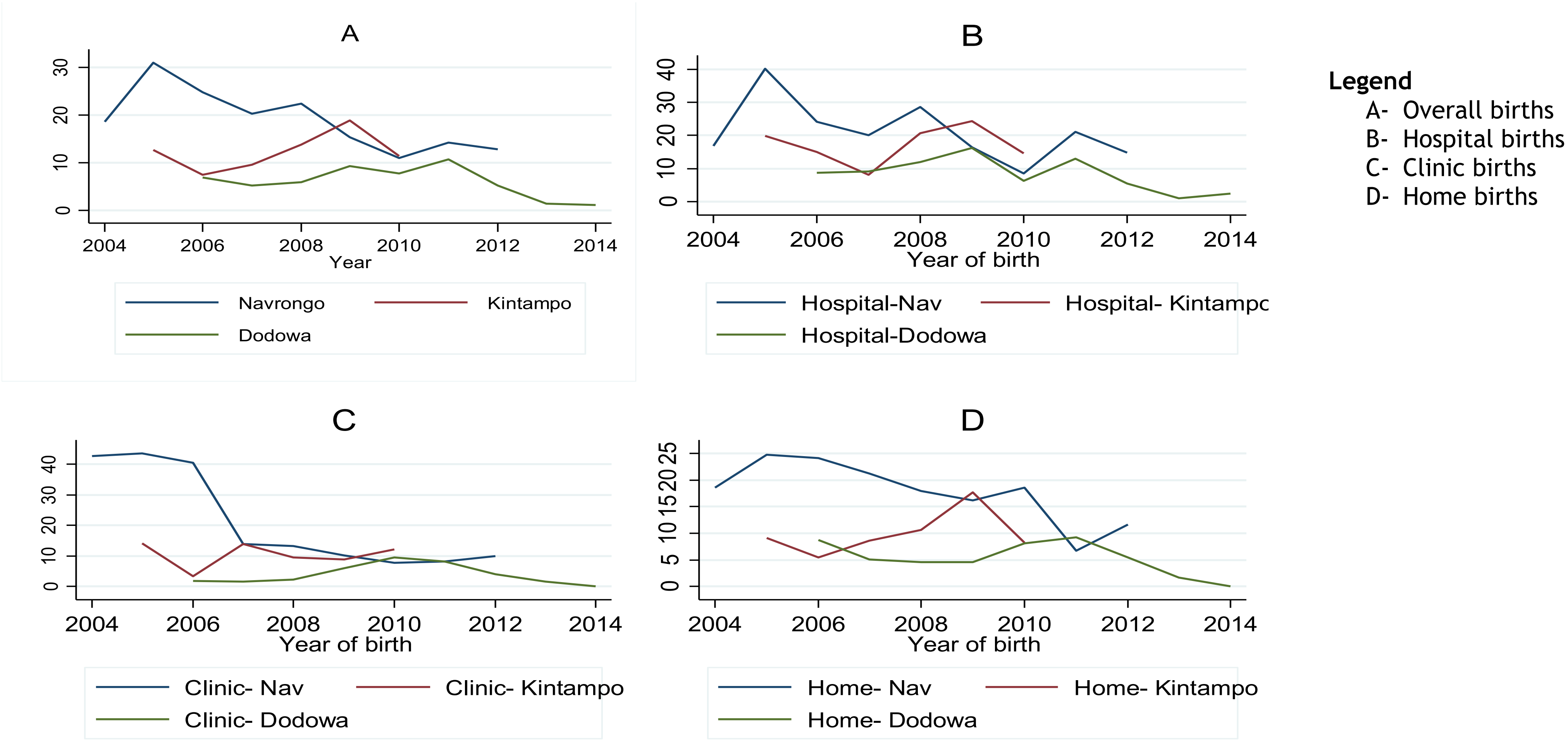


Fig 4.6.2: Temporal trends in NMR by region in each delivery service, 2004-2014

(**NB**: Unequal scale applied between place of delivery- emphasis of graph is between regions at same place of delivery)

Fig 4.6.2 depicts the temporal trends in NMR in Ghana by region, stratified by place of delivery. The line graph shows that overall, NMR in Ghana decreased over the study period. Overall (A), NMR was highest in the Navrongo HDSS, up to 2009 and lowest in Dodowa throughout the study period. The association was similar for hospital and clinic births. Among babies born at home, Navrongo had the highest NMR throughout the study period and Dodowa had the least.

4.6.3.2 Age at death

Overall, 595 babies died in the three HDSS during the study period. Of these 439 (73.8%) died in the early neonatal period and 156 (26.2) died in the late neonatal period. Of the early neonatal deaths, 46% died on the day of birth. The leading cause of neonatal deaths in the Navrongo and Kintampo were infection, asphyxia and prematurity.

Table 4.6.5: Distribution of neonatal deaths by region

	Navrongo	Kintampo	Dodowa	Total
All deaths	320	140	135	595
Age at death				
Day 0	90	55	58	203
1-6 days	133	48	55	236
7-27 days	97	37	22	156
Cause of death*				
Prematurity & LBW	55	7	-	62
Asphyxia	71	34	-	105
Infection	87	34	-	121
Neonatal jaundice	40	-	-	-
Congenital	3	-	-	-
Assault and accident	7	-	-	-
Others	13	30	-	43
Not known	27	14	-	41
Missing	16	21	-	37
*Data for causes of death in Dodowa was not provided				

4.7 Discussion of Ghana HDSS results

4.7.1 NMR

This chapter reported an overall NMR of 12 for the three Ghanaian regions studied, which is far lower than the NMR of 29 for the whole of Ghana reported in the 2014 Ghana demographic and health survey (DHS) (10), but significant regional differences were found. The NMR in Kintampo (12.5) was about twice the rate in Dodowa (6.2), and the Navrongo rate (18.8) was about three times the Dodowa rate. The differences in NMRs between the study areas remained significant when the data were restricted to the period 2006-2010 for which birth information was available in all three surveillance sites. It was expected that among the three HDSSs, Navrongo would have the highest NMR and this could be a reflection of the inequality in access to quality health services and high level of deprivation between northern and southern Ghana where Navrongo and Dodowa are located respectively (10).

There is good reason to believe that the NMR in this study may have been underreported. In Kintampo for example, this thesis reported a NMR of 12.5 between 2005-2010. This is far lower than the NMRs reported in two previous cluster randomized controlled trials in the same region (Obaapa Vit A trial, 2003-2004, NMR=30; Newhints trial, 2008-2009, NMR=31). Since the Obaapa Vit A trial (59, 231, 232) covered four out of seven districts in the Brong Ahafo region and the Newhints trial (233, 234) covered all seven districts but this thesis was restricted to only two districts in the Brong-Ahafo region, it could argued that, perhaps, the two districts in this thesis had the lowest NMRs. Given that the trials used more rigorous methods of follow up of the mothers in the region (at least once every four weeks), but in this thesis, mothers were only followed up evey six months, it is more reasonable to suggest that some neonatal deaths were missed. The extremely low NMR of 6 in Dodowa, could also be an artefact of poor measurement or missing data. In 2011, the NMR in Dodowa was 10.5. This was followed by a sharp decline to 5.1 in 2012 and another sharp decline to 1.1 in 2014. Whichever interventions led to such a drastic decline in NMR in so short a time deserves serious attention. But in the absence of any evidencefor such interventions, and given the proportions of missing data and the absence of a cause of death variable, a reasonable level of scepticism about the accuracy of the data is legitimate. Notwithstanding these discrepancies, mortality rates calculated from the actual numbers of all neonatal deaths and all live births in defined populations who were followed throughout pregnancy and post-partum are preferable to rates which are estimated from samples using complex statistical models and are subject to sampling and non-sampling errors (10).

Navrongo is the oldest of the three HDSS in Ghana with a well-established and reliable community key informant (CKI) system. These CKIs report deaths shortly after they occur and routine home visits in Navrongo are more frequent (three times per year in Navrongo compared to two times a year in Kintampo and Dodowa). Personal conversation with the Director of the Dodowa HRC suggested that the CKI system in Dodowa was not very efficient and deaths were reported long after they have occurred, if at all. In a culture which teaches mothers not to mourn perinatal death and keeping silent over neonatal death is encouraged (235-237), it is possible that the neonatal deaths in Dodowa were heavily under-reported. Elsewhere in Ethiopia and Tanzania, women were advised to accept neonatal death as the will of God, and “not to think about it” lest they offended God and suffer further consequences (235-237). Efforts to revamp the Dodowa HDSS system are underway. There was an overlap in NMR between hospital and clinic births in Navrongo and Kintampo, and the NMR differences between Navrongo and Kintampo appeared to be largely driven by home births (Table 4.6.4). It is therefore encouraging to know that the Navrongo HDSS has banned home deliveries and it is recommended that other regions in Ghana consider gradually replacing home deliveries with clinic facilities.

It is very encouraging to observe that the NMRs in all three HDSSs are reducing. Without further investigations, it would be hard to pinpoint the individual interventions which may have contributed to the year-by-year reduction in NMR in each HDSS. Generally, the lower NMR in the HDSS areas could be attributed to the multiplicity of health interventions and research initiatives which occur in these surveillance sites. In the Navrongo HDSS for example, the CHPS initiative which assigned nurses to community locations to provide curative and preventive care (62-64) and the intermittent preventive treatment for malaria in infant trial (60, 61) led to improved access to maternal care and significant reductions in maternal and infant mortality rates. In the Kintampo HDSS, the famous Obaapa Vit A (59, 231, 232) and Newborn health intervention studies (Newhints trials)

(233, 234) have also been found to have led to improved newborn outcomes. It will be necessary for further research to explore the individual contributions of these interventions to the reduction in overall NMR, and identify other programmes that could sustain the decreasing NMR, in order for the third Sustainable Development Goal of reducing NMRs to less than 12 by 2030 to be achieved.

4.7.2 Place of delivery and neonatal mortality

Most babies in the HDSS areas were delivered in a health facility (hospital: 38.1%, clinic: 21.1%), but there were significant regional differences. In Ghana, facility birth is synonymous with skilled delivery and home birth with delivery conducted by an unskilled person. In Navrongo (58%) and Dodowa (65%), the majority of babies were delivered in a health facility but in Kintampo the majority (51.6%) of babies were delivered at home. This corroborates results from the recent DHS which reported that 73% of women in Ghana delivered in a health facility (10). Of the three regions involved in this study, the DHS showed that the Greater Accra region, where Dodowa is located, had the highest proportion of facility deliveries, followed by the Upper East region where the Navrongo HDSS is situated. The Brong Ahafo region where Kintampo is located had the lowest proportion of facility deliveries. These regional differences could be a result of the largely urban nature of the Greater Accra region, where Accra-Ghana's capital is located, compared to the Upper East and Brong Ahafo regions which are largely rural (27, 238). Nevertheless, Navrongo may have had a higher proportion of facility-based deliveries compared to Kintampo because of the widespread presence of CHPS compounds which has increased access to skilled delivery in the region (62-64). It is expected that the proportion of facility-based deliveries in Navrongo will increase further because of the recent ban on home births. It raises genuine concerns, however, that the majority of babies born in Kintampo are still delivered at home. This could be due to the period covered by the data from Kintampo (2005-2010), compared to Navrongo (2004-2012) and Dodowa (2006-2014), and it is hoped that future analyses based on more current data could potentially reveal that institutional delivery is increasing in this region (10).

Perceptions that increasing facility-based deliveries will automatically lead to improvements in neonatal outcomes are overly simplistic, and previous studies are inconclusive (43, 98). This thesis found that, overall, hospital delivery had the highest NMRs compared to home deliveries and clinic deliveries had the lowest NMRs. In Navrongo and Kintampo, hospital delivery was associated with higher risk of early neonatal death but not late neonatal death and in Dodowa it was a higher risk for deaths on the day of birth only. In Navrongo, clinic delivery was associated with a lower risk of death throughout the neonatal period, in Kintampo it was associated with a lower risk of death on the day of birth, and in Dodowa it was a lower risk for deaths after the first day. Bluntly put, this finding suggests that hospital birth may not be good for women but clinic delivery is. This was unexpected, and at face value it seems counter-intuitive, given the clinical skills and resources in hospitals compared to home delivery settings. However, putting such crude information in the public domain without considering the characteristics of neonatal deaths would be very misleading.

It is possible that the high risk of neonatal mortality among hospital births was due to high risk pregnancies which are transferred from clinics and home births to hospitals, and whilst I adjusted for all available and measured confounders, residual confounding is still possible. This study showed more multiple births and first births in hospitals than clinics and homes, and these are known risks for neonatal mortality (45, 239, 240). An exploration of the neonatal death profiles also revealed that the majority of deaths occurred at home, including those who were born in the hospital. There were more babies who were born in hospital but died at home or elsewhere (hosp/home), especially deaths which occurred in the first week, compared to those born at home but died in hospital (home/hosp). In Navrongo, for example, 40% of the neonatal deaths who were born in hospital died at home, compared to only 14% who were born at home but died in a hospital (Table 4.3.9, Fig 4.3.5). Among these, 7 of the hospital births died at home on the day they were born compared to only 3 home births that died in a hospital on the day of birth. Similar excess mortalities at home were observed among hospital births in Kintampo (Table 4.4.9, Fig 4.4.5) and Dodowa (Table 4.5.14, Fig 4.5.6). It is unconscionable that babies born in a hospital go home to die on the same day of birth. This strongly suggests that babies born in hospital may have been discharged home too early without receiving appropriate immediate postnatal care or discharge assessment. The fewer number of babies who are born at home but died in hospital (home/hosp) also suggest a failure to get sick babies from home to hospital. Many studies have indicated a poor health seeking behaviour for neonatal illness among mothers in Ghana and other developing countries (86, 99, 154).

There has been recent widespread promotion of facility-based delivery (241, 242), especially following the seminal paper by Lawn et al., (5) which found that most newborn deaths in developing countries occur at home, and consequently recommended increasing investment to scale up facility-based delivery (243). In Ghana, free maternal delivery, widespread CHPS facilities and in some places a total ban on home deliveries have directly resulted in the decline in home deliveries (244). The resultant pressure on limited health facilities and insufficient human resource may have caused clinicians to discharge mothers too soon after delivery without proper assessment. Anecdotal evidence suggests that, in some hospitals, there are not enough beds to admit mothers and some slept on the floor. In Navrongo, Moyer, Adongo et al. (108) have documented a cultural transition from home delivery to facility-based delivery. Unfortunately, this ‘cultural transition’ does not appear to have affected skilled care for newborn illnesses, and mothers continue to seek traditional approaches for neonatal diseases. Other contextual factors affecting care seeking for neonatal diseases, including cultural and belief patterns have also been noted (99, 108, 154). Overemphasising where babies are born without considering where they are cared for, may therefore produce misleading results.

After excluding babies who died in settings other than where they were born, a multivariable regression analysis showed that in Navrongo, babies born in hospital had a 25% significant lower risk of death in a hospital (hosp/hosp) and those who were born in clinic had an 85% lower risk of death in a clinic (clinic/clinic), compared to babies born at home. This suggests that a combination of skilled delivery and skilled care is associated with better newborn outcomes than home delivery and home care. In Dodowa, hospital births remained at increased risk of neonatal death in a hospital (hosp/hosp) but clinic births were at lower risk of death in a clinic (clinic/clinic). It is plausible that the high risk associated with hospital births was due to the high-risk pregnancies which are transferred from homes or clinics to hospitals. I did not have detailed information regarding referral, where delivery started nor mothers’ medical histories. It is reasonable to assume that high risk deliveries, including preterm babies and breech deliveries, may have been transferred from home or clinic settings to hospitals. As a consequence, the high risks associated these deliveries may have been transferred to hospitals, thus exaggerating the risks associated with hospital delivery (245). Anecdotal evidence suggests that while midwives in clinics were able to determine high risk pregnancies and thus referred them in time, TBAs encouraged mothers to try labour at home and made referrals when it was too late. In Kintampo, babies born in a health facility were more likely to die in a health facility than those born at home. The Kintampo data did not distinguish between babies who died in hospital from those who died in clinic. Therefore, it is possible that the high risk among facility-based deliveries was driven by hospital births.

Improving postnatal care particularly community based care for newborn illness by skilled personnel is an important policy recommendation from this study. This would involve equipping existing community nurses with essential skills to assess and treat minor newborn illnesses at home. This needs to be supported by an efficient referral system and access to emergency services. Antenatal education of mothers should also include warning signs to look for during the immediate postnatal period and encourage mothers to seek early treatment for newborn diseases. It is suggested that advocates of facility-based delivery should also include facility-based care in order to achieve optimum neonatal outcomes. Ideally, this will include keeping mothers a little longer in the health facilities to allow sufficient time for monitoring before discharge and adequately resourcing hospitals to manage high risk deliveries.

4.7.3 Age at death and causes of death

The risk of death is not constant across the neonatal period; NMR attenuates with increasing age of the baby, with the day of birth having the highest risk for neonatal death. In all three research sites, at least 70% of the total neonatal deaths occurred in the first week, and 28%-53% occurred on the day of birth. The leading causes of neonatal death were prematurity, asphyxia and infection. Asphyxia and prematurity were the leading causes of death in the early neonatal period- with asphyxia responsible for the majority of deaths on the day of birth, and infection the leading cause of late neonatal deaths. These are consistent with global, regional and national estimates (5, 28, 47, 57).

Overall, asphyxia was the leading cause of death among hospital births and hospital deaths and infection was the leading cause of death among home births and hospital deaths. When stratified by where the baby was born and where s/he died, asphyxia was the leading cause of death among babies who were born in a hospital and also died in a hospital (hosp/hosp). Infection was the leading cause of death among babies who were born in a hospital but died at home (hosp/home), those born at home but died in a hospital (home/hosp) and those born at home and also died at home (home/home). This is a very important finding which shows a huge potential to reduce neonatal deaths due to asphyxia in health facilities and deaths due to infections at home. Unfortunately, the cause specific NMR for asphyxia appears to be increasing. There is thus an urgent need for interventions to reduce deaths due to asphyxia especially in hospitals and deaths due to infections at home.

The fact that many babies who are born in hospital and also die in hospital die in the first week because of asphyxia raises questions about the quality of intrapartum care, the skills of clinicians and the availability of equipment to manage asphyxiated babies in these health facilities (125, 126). The causes of birth asphyxia are well known (246, 247) and the degree of injury caused by asphyxia is dependent on the duration of ischemia or hypoxia. If oxygen loss is not restored within minutes, babies could suffer seizures or even long-term complications including cerebral palsy, hypoxic ischemic encephalopathy, permanent brain damage, and other organ malfunctions (248, 249). Preterm babies are at increased risk of these complications (250). Fatal consequences of asphyxia are avoidable if appropriate interventions are taken on time: appropriate monitoring of mother and baby in utero before and during labour, resuscitation of the asphyxiated baby, or more advanced mechanical ventilation support. WHO has compiled a guideline for the management of newborn complications (251). The Ghana National Newborn Health Strategy (38) and Action Plan aims to train at least 90% of skilled birth attendants in essential newborn care by 2018. It is strongly recommended that efforts to meet this target are expedited by organising training workshops, for example Helping Babies Breathe (252, 253), for all maternity care providers. Such educational programmes should be complemented with ongoing skills practice, monitoring and refresher training or drills to ensure care providers maintain their skills (254).

The fact that infection was the main cause of death in babies who were born and died at home is indicative of poor conditions in which babies are delivered at home, poor newborn care practices or how infections are managed at home. Previous studies have reported poor newborn care practices, including application of herbs to the umbilical cord which predispose babies to infection (78, 79). Common infections reported in central and northern Ghana include septicaemia, pneumonia, meningitis, diarrhoea and tetanus (57, 59). There is also evidence that the first point of call for mothers regarding neonatal illnesses is a relative or traditional healer because beliefs that newborn infections may be spiritual still exist (78, 79, 108, 154). Hospitals also do not have essential laboratory apparatus to diagnose infections and so the exact cause of infections remains a mystery. Improving medical services to accurately diagnose neonatal infections, improving access to postnatal care and public education to demystify spiritual causes of diseases are needed to encourage mothers to seek treatment from skilled care providers.

The differences in causes of death among babies born in health facilities and those born at home begs more questions regarding the skills of maternity care providers. It is important for further studies to explore how neonatal complications are managed by care providers in different birth settings. This will help public health interventions to be tailored towards directly improving how babies are cared for. Chapter 6 of this thesis assesses equipment available to maternity care providers to manage the various newborn complications and chapter 7 explores how birth complications are managed by health care providers, as well as the contextual factors that may contribute to neonatal mortality in these settings.

4.7.4 Risk factors for neonatal mortality and place of death

Consistent with previous studies, this thesis found that babies born to educated mothers were less likely to die in the neonatal period compared to those born to uneducated mothers, but first births, twins and boys (27, 45, 57) were at significantly increased risk of neonatal mortality. It was interesting to note that the socioeconomic status of the mother, measured as household assets, was not related to neonatal mortality. It has been suggested that widespread implementation of CHPS may have offset the dire consequences of poverty in northern Ghana (57). In addition, the policy of free maternal delivery in Ghana ensured that all pregnant women were registered with the National Health Insurance Scheme at no premium. This insurance also covers the newborn throughout the neonatal period until the third month after birth. Thus, direct healthcare expenditure has been removed, or at least minimised (255). Previous studies in the UK have shown that twins, especially second twins delivered at term via vaginal delivery are at increased risk of death due to intrapartum anoxia (149, 150). This is largely due to difficulties in monitoring in utero and the increased likelihood of traumatic delivery following vaginal delivery of the first twin (149). It has been suggested that planned caesarean section could reduce deaths of twins by about 75% (149). Boys may be at higher risk of death in the neonatal period due to differences in birthweight (138) or a higher proportion of preterm deliveries (256). The association between maternal age and neonatal mortality was not conclusive. Overall, mothers aged over 30 had a higher risk of neonatal mortality. This was similar to the findings in Kintampo but, in Navrongo, older mothers were at lower risk of neonatal mortality and, in Dodowa, there was no association between maternal age and neonatal mortality. Previous studies about the relationship between maternal age and neonatal mortality have also yielded conflicting findings (27).

4.7.5 Strengths and limitations

This thesis is one of the largest on neonatal mortality in Ghana. I analysed population data from three geographically distinct and well defined surveillance areas in Ghana. These HDSSs use apparently robust methods to collect birth and death information on all people in the population. Previous studies, including some population surveys, have estimated NMR from representative samples or relied on complex statistical modelling (10). It is also the first study to combine data from all three HDSS in Ghana, which allowed me to compare results from the three regions. By analysing neonatal death profiles, this study provides a clearer understanding as to why babies born in hospital may be at higher risk of death. The implicit assumption had been that deaths are related to delivery related activities in those health facilities. It is therefore recommended that future studies focus more on neonatal deaths related to delivery related activities only, for example birth asphyxia. Previous studies have been restricted to simple descriptive statistics (14, 59) or did not distinguish clinics from hospitals although there are systemic differences (57, 59). This study also used appropriate statistical techniques to cater for the lack of independence between babies born of the same mother or same household.

There are several methodological limitations in this study that need to be acknowledged. The first, and main, concern was the quality of some recorded variables. There were large amounts of missing data on variables like ANC attendance and personnel who attended the delivery and some variables, such as mode of delivery, were recorded for only dead babies and so could not be included in the multivariable analyses. Where it is plausible to assume that data were missing at random, I used multiple imputation techniques to model possible values for missing data. While there are statistical techniques to help mitigate the problem of missing data, the stability of the models becomes problematic in the light of very large proportions of missing data or complex models. As previously indicated, the NMRs in this study may have also been underreported due to poor follow-up and missing data. Concerns about the lack, or poor quality, of data from developing countries have been raised by many researchers (5, 30, 257, 258). It is strongly recommended that the HRCs which manage these HDSS conduct regular quality assurance checks to ascertain and to ensure the accuracy of the data collected.

Data from the three HDSS could not be combined due to differences in the methods and measurements for the recorded variables. Socioeconomic status, for example, was based on principal component analyses of items characteristic of a given region, and categories were based on quintiles within the region. Thus it was possible for a woman classified poor in Dodowa to be equivalent to an average, or even rich woman in Navrongo. It is hoped that this study while showing differences between the regions, will highlight the need for standardised tools for collecting data in these three HDSSs. Although this study analysed data from 2004-2014, verbal post mortem (VPM) data are available for data for only 2005-2010 (The Dodowa HDSS did not provide VPM data and more recent VPM data from Navrongo have not yet been coded). It is encouraged that these VPM data be coded to increase the power of future studies and future studies should cover more regions or years to be sufficiently powered to observe significant associations.

An association between place of birth and neonatal mortality does not imply causality because alternate explanations are plausible. This study lacked data on some potentially confounding maternal and obstetric variables (height or BMI at booking, Apgar score, mode of delivery, presentation, birth weight and maternal conditions). Gestation could be a proxy for birthweight (57), but the gestation in this study was based on mothers recall of her last menstrual period, rather than an early ultrasound scan, which is unlikely to be precise but may not differ systematically between mothers who experienced neonatal death and those who did not. It is recommended that the HDSSs revise their data collection tools to include these relevant variables.

Chapter 5 Neonatal mortality in Scotland

5.1 Introduction

This chapter presents the methods and results from analyses of the Scottish maternity records (SMR02) and neonatal death records. These analyses form part of the 2ºQUAN phase of the overall multilevel mixed methods design, described in chapter 3. The SMR02 and perinatal death data, 1992-2015, were provided by the Information Services Division (ISD) of the Scottish National Health Service (NHS, Scotland) following approval from the Privacy Advisory Committee. The primary aim of these analyses was to determine the NMR and trends in Scotland and investigate the factors associated with neonatal mortality.

5.2 Methods

5.2.1 Methods for SMR02 and NRS data collection

In Scotland, routine data on all women who attend maternity hospitals, as inpatients or day cases, are recorded in the Scottish Morbidity Record- number twoscore (SMR02) and data on stillbirths and infant deaths are available from the National Record of Scotland's Stillbirth and Infant Death Register (NRS). Demographic and clinical information in the SMR02 are recorded and coded by staff in the health facilities using information from the discharge summary and clinical notes. These are coded into the hospital's information systems and then sent to the ISD. In Scotland, it is mandatory to register all perinatal deaths with the General Register Office which issues the death certificates. Deaths and causes of death are certified by medically qualified personnel and coded by designated personnel at ISD on the basis of post mortem and/or other medical information available and the advice of a clinical advisor. The medical causes of perinatal death are coded according to the International classification of Diseases (ICD-9 or ICD-10 from 2000 onwards) system.

The Data Quality Assurance (DQA) team at ISD checks the accuracy, consistency and completeness of these datasets. Data recorded in the SMR02 records undergo regular quality assurance checks and have been shown to cover 98% of all births and pregnancies in the country (103). As a result, Scotland has one of the best information on pregnancy and births in the world. The last quality check of the SMR02 dataset compared a sample of the national database (n=2,531) between May 2008 and August 2009 with their medical records in the hospitals. It was found that 53% of the 34 data items assessed were at least 90% accurate in comparison with the information recorded in the medical record (103). Five out of seven of the variables in this study which were included in the quality check were found to be at least 90% accurate: number of births in this pregnancy (100%), sex (100%), birth weight (99%), Apgar score (93%), gestation (92%). Only two were less than 90% accurate: mode of delivery (87%) and smoking at booking (81%).

5.2.2 Data management

Singleton birth records in the SMR02 covering the years 1992-2015, linked to the NRS data, were extracted by an assigned research coordinator in ISD. The SMR02 contained demographic and clinical data on all babies and their mothers, while the NRS data contained mortality information including cause of death on all babies who died. These files were anonymised and deposited in a secure environment, known as the Safe Haven, where all statistical analyses were undertaken using a remote virtual private network (VPN) link. No information could be copied into or out of the safe haven unless it was approved by the assigned research coordinator who ensured that no identifiable individual level data were produced. The Scottish data were restricted to only singleton records because of its high quality and problems regarding linking multiple pregnancies with maternal data. Previous studies have analysed these multiple births data exclusively (149, 150).

The SMR02 and NRS data files were received in *.csv* formats and converted to Stata compatible formats. These datasets were independently cleaned and merged using the unique individual ID and year of birth of the baby contained in both files. Duplicate data, stillbirths and abortions were removed from the final dataset. All unfeasible values in the final dataset were treated as missing values. The original SMR02 file contained data on 1,287,026 mothers and babies born between 1992 and 2015 and the NRS extract contained data on 11,899 infant deaths, including stillbirths and abortions. After removing duplicates (n=2,422) from the SMR02 data, the remainder were linked with the NRS file using the unique baby ID and year of birth in both files. After excluding stillbirths and abortions (n=6,919), the final dataset contained information on 1,278,846 mothers and live born babies, including 2,783 neonatal deaths. The results presented in this chapter are based on analyses of the data in this final dataset.

5.2.3 Ethics approval

Applications to use patient data for research purposes in Scotland are managed by the Electronic Data Research and Innovation Service (eDRIS) of the Information Services Division (ISD) http://www.isdscotland.org/Products-and-Services/eDRIS/. The process for requesting data from ISD required me to undertake an information governance course by the Administrative Data Liaison Service (ADLS) entitled ADLS Safe Researcher Training (Appendix 2.1) and then submitting a completed application form to the then Privacy Advisory Committee (PAC), now the Public Benefit and Privacy Panel (PBPP) http://www.adls.ac.uk/nhs-scotland/maternity-inpatient-and-day-case-smr02/?detail. The PAC application included details of the research proposal, list of variables being requested and a justification for why they were required. Upon successful application, anonymised data were released into the 'Safe Haven' within which all statistical analyses were conducted remotely. Only aggregated results were permitted to be exported from the Safe Haven after approval by an assigned research coordinator. My application to use Scottish data was granted in June 2015, under the study ID eDRIS-1516-0144 (Appendix 2.2).

5.2.4 Statistical analyses

Cross tabulations comprising frequencies, column percentages and NMR were used to summarise the characteristics of mothers and babies born in Scotland between 1992-2015 by whether or not the baby died within 28 days of birth. Pearson's chi square tests for categorical variables and chi square test for trends for temporal and ordered categorical variables were used to test the statistical significance of any differences observed. The risk of neonatal death was modelled using binary logistic regression analyses, both univariately to produce crude odds ratios and multivariately to produce adjusted odds ratios. The multivariable regression models were adjusted for the following potential confounding factors: deprivation, maternal age, parity, sex, marital status, five minute Apgar score, gestation, birthweight, smoking status at booking, maternal hypertensive disorders, previous neonatal death and previous stillbirth. The confidence intervals for the multivariable model were based on cluster robust standard errors, to take account of the lack of independence between babies born to the same mother over the study period. All statistical tests were performed in Stata MP version 14 and statistical significance was two-sided and set at p=0.05.

Nearly 40% of the observations in the original dataset were omitted in the multivariable model using the complete cases due to missing data on one or more variables. Multiple imputation (MI) techniques was therefore used to generate ten additional datasets (*m*=10) with simulated values for the missing data, after ensuring that the underlying assumptions for MI were met. (The large size of the data did not allow me to create 40 imputed datasets but I do not think this impacted the results in any way). The principles and methods for multiple imputation have already been explained in Chapter 4 of this thesis. The imputation model included identical variables utilised in the multivariable model for the complete cases. Multiple imputation was conducted using Stata's multiple imputation by chained equations (MICE) because this allows the distribution of each variable in the model to be specified. Binary variables, for example sex and previous stillbirths, were modelled using binary logistic regression (*logit*), ordered categorical variables, for example deprivation and maternal age, were modelled using ordered logistic regression for nominal variables (*ologit*) and nominal variables were modelled using multinomial logistic regression (*mlogit*). Birthweight was modelled using a truncated regression (*truncreg*) within pre-specified ranges based on the birthweight distribution for boys and girls. Perfect predictions in the imputation model were corrected for using Stata's automated augmentation process. Similar to the multivariable model for the complete cases, the confidence intervals for the adjusted odds ratios for the imputed model were based on cluster robust standard errors, to take account of non-independence between babies born to the same mother.

5.2.5 Definitions of variables

The list of variables contained in the final dataset is described below. Since similar definitions are used in the HDSS data (in Chapter 4), this section describes only additional variables not previously defined in section 4.2.4. All this information was recorded from the clinical records of mothers and babies who used maternity services.

1. *Deprivation*: The Scottish index of multiple deprivation (SIMD) was used to assess the mother's socioeconomic status. SIMD is an area-based measure of deprivation in Scotland based on multiple indicators including income, employment, education, health, access to services, crime and housing. SIMD ranks small areas in Scotland, known as datazones (containing population of between 500 and 1000 household residents), from 1 to 6,976 for the most deprived to the least deprived areas respectively. Further details of SIMD are available at http://www.gov.scot/Topics/Statistics/SIMD. In this study, SIMD scores were categorised into quintiles for the study population with 1=most deprived and 5=least deprived.
2. *Maternal age*: This refers to the age of the mother at the time of booking. Mothers recorded as aged less than 13 or more than 60 years were treated as missing values.
3. *Apgar*: The Apgar score is a physical measure of the baby's health at the first and fifth minute after birth. Developed in 1952 by Virginia Apgar, it is also an acronym for measures of Appearance, Pulse, Grimace, Activity and Respiration (259). Each of these five components is rated out of 2 (0-Poor, 1-Average, 2-Good) to give an overall score of 10. The overall Apgar scoring system is usually categorised as 0-3, 4-6 and 7-10 for poor, average and good respectively. This study used the Apgar score at 5 minutes to assess the wellbeing of the baby.
4. *Birthweight*: Refers to the weight of the baby at birth using standard techniques as measured by the attending midwife. Birthweights recorded as <400g and >6,000g were treated as missing values.
5. *Smoking at booking*: This refers to the woman's self-reported smoking status at the time of the first antenatal visit, categorised as never smoker if she had never smoked, current smoker if she was an active smoker at the time of the first visit, and former smoker if she had smoked previously but was no longer an active smoker.
6. *Maternal diseases*: Maternal diseases included in this study were hypertensive disorders, pre-eclampsia and eclampsia. These were

diagnosed by the attending physicians and coded according to the ICD-9 and ICD-10 classifications.

5.3 Results

The results show that overall 1,278,846 singleton livebirths were delivered in Scottish health facilities between 1992 and 2015 inclusive. Of these, 2,783 died within 28 days of birth, equivalent to an NMR of 2.2 per 1,000 livebirths.

5.3.1 Characteristics of neonatal mortality and NMR in Scotland

Table 5.3.1 summarises neonatal deaths and NMR according to the characteristics of the mother. The table shows significant differences between babies who died and those who did not die by all the listed maternal characteristics. Younger mothers (<20 years) and older mothers (>40 years), most deprived mothers, those not married, those with a history of neonatal death or stillbirth, mothers with at least three previous babies, those delivered by caesarean section and mothers who smoked at the time of first antenatal visit were more likely to experience neonatal deaths. Mothers who had a breech delivery, those who had five or more previous babies and those with a history of neonatal mortality had the highest NMRs.

Table 5.3.1 Summary of maternal characteristics by neonatal death

Variable	Alive n (%)	Dead n (%)	Total N (%)	p-value	NMR
All	**1,276,063**	**2,783**	**1,278,846**		**2.2**
Maternal age					
<20	93,604 (7.3)	268 (10.9)	93,872 (7.3)	<0.001	2.9
20-29	610,199 (47.8)	1,192 (48.4)	611,391 (47.8)		1.9
30-39	538,891 (42.2)	932 (37.8)	539,823 (42.2)		1.7
40+	33,217 (2.6)	72 (2.9)	33,289 (2.6)		2.2
Missing	152	319	471		
Deprivation					
1=Most deprived	335,132 (26.4)	750 (30.6)	335,882 (26.4)	<0.001	2.2
2	264,168 (20.8)	570 (23.2)	264,738 (20.8)		2.2
3	234,476 (18.4)	422 (17.2)	234,898 (18.4)		1.8
4	221,791 (17.5)	389 (15.9)	222,180 (17.4)		1.8
5=Least deprived	215,700 (17.0)	323 (13.2)	216,023 (17.0)		1.5
Missing	4,796	329	5,125		
Marital status					
Single	358,614 (31.9)	744 (33.2)	359,358 (31.9)	<0.001	2.1
Married	533,566 (47.5)	1,052 (46.9)	534,618 (47.5)		2.0
Widowed	694 (0.1)	2 (0.1)	696 (0.1)		2.9
Divorced	3,576 (0.3)	12 (0.5)	3,588 (0.3)		3.3
Separated	2,518 (0.2)	11 (0.5)	2,529 (0.2)		4.3
Other	71,708 (6.4)	175 (7.8)	71,883 (6.4)		2.4
Not known	152,136 (13.6)	245 (10.9)	152,381 (13.5)		1.6
Missing	153,251	542	153,793		
Previous neonatal deaths					
0	1,003,756 (99.5)	1,731 (97.4)	1,005,487 (99.5)	<0.001	1.7
1	5,061 (0.5)	42 (2.4)	5,103 (0.5)		8.2
2+	430 (0.04)	5 (0.3)	435 (0.04)		11.5
Missing	266,816	1,005	267,821		
Previous stillbirths					
No	1,001,697 (99.3)	1,750 (98.4)	1,003,447 (99.3)	<0.001	1.7
Yes	7,549 (0.8)	28 (1.6)	7,577 (0.8)		3.7
Missing	266,817	1,005	267,822		
Parity					
0	576,128 (45.2)	1,243 (44.7)	577,371 (45.2)	<0.001	2.2
1	437,837 (34.3)	685 (24.6)	438,522 (34.3)		1.6
2	171,833 (13.5)	302 (10.9)	172,135 (13.5)		1.8
3	55,763 (4.4)	132 (4.7)	55,895 (4.4)		2.4
4	17,888 (1.4)	38 (1.4)	17,926 (1.4)		2.1
5+	16,614 (1.3)	383 (13.8)	16,997 (1.3)		22.5
Mode of delivery					
Vaginal delivery	833,149 (65.3)	990 (40.2)	834,139 (65.3)	<0.001	1.2
Instrument	155,837 (12.2)	136 (5.5)	155,973 (12.2)		0.9
Caesarean section	283,041 (22.2)	940 (38.1)	283,981 (22.2)		3.3
Other/ breech	3,886 (0.3)	399 (16.2)	4,285 (0.3)		93.1
Missing	150	318	468		
Smoking history at booking					
Never smoker	746,121 (64.0)	1,162 (57.1)	747,283 (64.0)	<0.001	1.6
Current smoker	300,495 (25.8)	713 (35.1)	301,208 (25.8)		2.4
Former smoker	119,895 (10.3)	159 (7.8)	120,054 (10.3)		1.3
Missing	109,552	749	110,301		
Hypertensive disorders					
None	1,223,124 (95.9)	2,692 (96.7)	1,225,816 (95.9)		2.2
Pre-existing HTN	12,325 (1.0)	10 (0.4)	12,335 (1.0)	<0.01	0.8
Pre-eclampsia/ Eclampsia	40,614 (3.2)	81 (2.9)	40,695 (3.2)		2.0
HTN: Hyptertension					

Table 5.3.2 summarises the characteristics of babies by neonatal death and NMR by subgroup. The table shows significant differences in the sex of babies, estimated gestation, birthweight and Apgar score by dead or alive after 28 days. Boys, babies born before 37 weeks of pregnancy, those with low birthweight (<2.5kg) and those with an Apgar score of less than 7 at the fifth minute were more likely to die in the neonatal period. Babies born before 28 weeks, those who weighed less than 1.5kg at birth and those who scored 3 or less Apgar score at five minutes had the highest NMRs.

Table 5.3.2 Summary of neonatal characteristics by neonatal death

Variable	Alive n (%)	Dead n (%)	Total N (%)	p-value	Deaths/ 1,000
Sex					
Male	653,877 (51.3)	1,392 (56.8)	655,269 (51.3)	<0.001	2.1
Female	621,970 (48.8)	1,061 (43.3)	623,031 (48.7)		1.7
Missing	216	330	546		
Estimated gestation					
<28	2,415 (0.2)	965 (39.4)	3,380 (0.3)	<0.001	285.5
28-<32	7,790 (0.6)	278 (11.4)	8,068 (0.6)		34.5
32-<37	62,530 (4.9)	392 (16.0)	62,922 (4.9)		6.2
37-<42	1,158,386 (90.9)	785 (32.1)	1,159,171 (90.8)		0.7
42+	43,404 (3.4)	28 (1.1)	43,432 (3.4)		0.6
Missing	1,538	335	1,873		
Birthweight/ g					
<1,500	8,761 (0.7)	1,124 (47.5)	9,885 (0.8)	<0.001	113.7
1,500-<2,500	59,461 (4.7)	409 (17.3)	59,870 (4.7)		6.8
2,500-4,000	1,045,819 (82.0)	742 (31.4)	1,046,561 (81.9)		0.7
>4,000	161,125 (12.6)	91 (3.9)	161,216 (12.6)		0.6
Missing	897	417	1,314		
Apgar at 5 minutes					
0-3	5,696 (0.5)	1,023 (45.9)	6,719 (0.5)	<0.001	152.3
4-6	12,770 (1.0)	407 (18.3)	13,177 (1.0)		30.9
7-10	1,245,685 (98.5)	798 (35.8)	1,246,483 (98.4)		0.6
Missing	11,912	555	12,467		

5.3.2 Temporal trends in neonatal mortality

This section shows the temporal trends in neonatal mortality and NMR in Scotland between 1992 and 2015. The table and graphs show that the NMR in Scotland declined by 62.5% from 3.2 in 1992 to 1.2 in 2015. Table 5.3.3 presents the distribution of neonatal deaths by year of birth. It shows that babies who were born before 2000 were more likely to die in the neonatal period and those born after 2006 were less likely to die.

Table 5.3.3 Temporal trends neonatal mortality and in NMR, 1992-2015

Variable	Alive	Dead	Total	P value	Deaths/1,000
	n (%)	n (%)	N (%)		
All	**n=1,276,063**	**n=2,783**	**N=1,278,846**		**2.2**
Year of birth					
1992	62,343	201	62,544	<0.001	3.2
1993	60,647	178	60,825		2.9
1994	58,933	134	59,067		2.3
1995	57,430	137	57,567		2.4
1996	55,690	146	55,836		2.6
1997	56,947	125	57,072		2.2
1998	54,825	127	54,952		2.3
1999	52,467	110	52,577		2.1
2000	50,796	136	50,932		2.7
2001	49,519	122	49,641		2.5
2002	48,783	99	48,882		2.0
2003	49,789	98	49,887		2.0
2004	51,454	106	51,560		2.1
2005	51,098	118	51,216		2.3
2006	51,727	99	51,826		1.9
2007	54,551	117	54,668		2.1
2008	56,617	109	56,726		1.9
2009	55,895	109	56,004		1.9
2010	55,822	111	55,933		2.0
2011	55,660	96	55,756		1.7
2012	55,018	95	55,113		1.7
2013	52,583	79	52,662		1.5
2014	52,788	101	52,889		1.9
2015	24,681	30	24,711		1.2

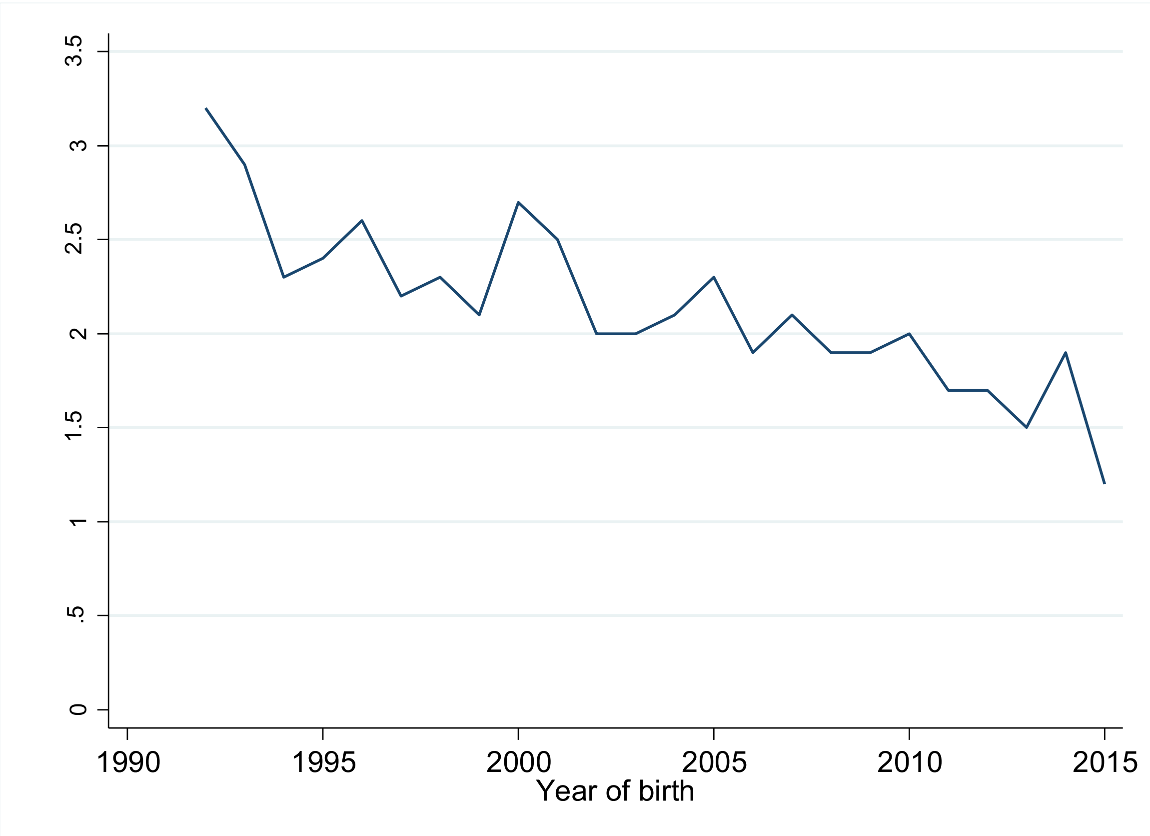


Fig 5.3.1 Temporal trends in NMR in Scotland 1992-2015

The line graph in Fig 5.3.1 shows that NMR in Scotland has declined steadily over the study period and the rate of decline is fairly consistent. The highest NMR was recorded in 1992 and the lowest was in 2015. (This also matches closely with published figures in the 2011 Scottish Perinatal and Infant Mortality and Morbidity Report (SPIMMR) (260))

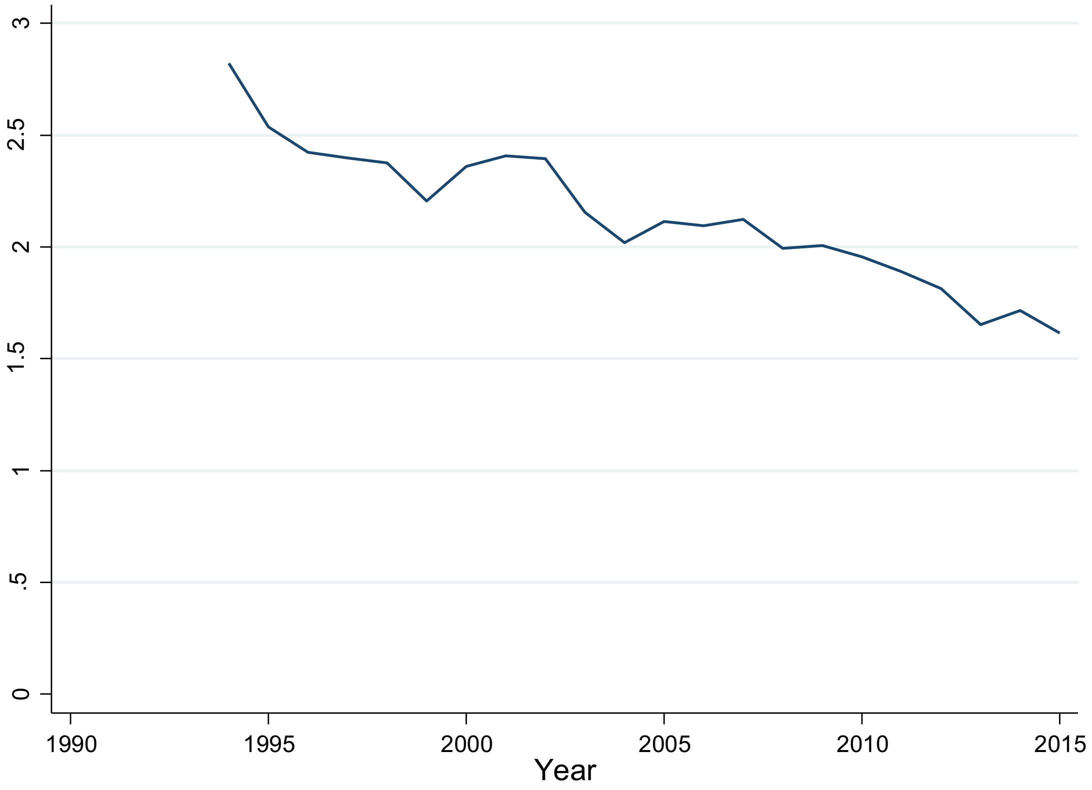


Fig 5.3.2 Three-year moving average NMR in Scotland, 1992- 1995

Fig 3.3.2 shows a three-year moving average NMR in Scotland from 1992 to 2015. The line graph shows a fairly steady decline in NMR in Scotland over the study period.

5.3.3 Factors associated with neonatal mortality in Scotland

Table 5.3.4 shows the results of univariate and multivariable logistic regression of the maternal and neonatal factors associated with neonatal mortality in Scotland. Results from the univariate analyses show that maternal age, deprivation, parity, smoking status at the time of booking, pre-existing hypertensive disorders and previous neonatal death and stillbirth were associated with neonatal mortality. All the neonatal factors, sex, Apgar score, gestation, and birthweight, were also significantly associated with neonatal mortality in the unadjusted analyses. After adjusting for the potential confounding factors, the multivariable analyses showed that none of the maternal demographic characteristics were related to neonatal mortality, except for single mothers, who were 32% (95% CI 18%-43%) less likely to experience a neonatal death compared to married mothers. Mothers who had experienced a previous neonatal death were two and half times more likely to experience neonatal death as those who never experienced a neonatal death. Mothers who had one previous child were 24% (9%-36%) less likely to experience neonatal death compared to first time mothers. The multivariable analyses also showed that boys, babies with low Apgar scores at five minutes, babies born before 37 weeks gestation and those who weighed less than 2.5kg at birth were more likely to die in the neonatal period.

Mothers who did not have hypertension had a higher risk of neonatal death compared to those with pre-existing hypertensive disorders, pre-eclampsia or eclampsia. Compared to never smokers, mothers who ever smoked (current and former smokers) appeared to be less likely to experience neonatal death and mothers who never smoked seemed to have a higher risk. When Apgar score, birthweight and gestation were removed from the multivariable model, smokers were significantly more likely to experience neonatal death (OR 1.27, 95% CI 1.12-1.45, $p<0.001$) and former smokers were less likely to experience neonatal death (OR 0.80, 95% CI 0.65-0.99, $p=0.04$). There was no association between any of the hypertensive disorders and neonatal mortality. The area under the ROC curve for the overall logistic regression was 91% suggesting a very strong model. A Hosmer-Lameshow test to check the goodness of fit showed non-significant results at varying degrees of freedom, indicative that the model was a good fit.

Table 5.3.4: Logistic regression analyses of factors associated with neonatal mortality in Scotland

	Univariate		Multivariable (N=769,596)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	p-trend
Mother's age					
<20	1.47 (1.28-1.67)	<0.001	0.90 (0.69-1.19)	0.47	0.35
20-29	1.00		1.00		
30-39	0.89 (0.81-0.96)	0.01	0.96 (0.81-1.13)	0.62	
40+	1.11 (0.87-1.41)	0.39	1.05 (0.68-1.61)	0.83	
Marital status					
Single	1.05 (0.96-1.56)	0.29	0.68 (0.57-0.82)	<0.001	
Married	1.00		1.00		
Widowed	1.46 (0.36-5.86)	0.59	1.80 (0.17-19.61)	0.63	
Separated /Divorce	1.91 (1.27-2.90)	0.01	2.99 (0.34-26.53)	0.33	
Other	0.82 (0.71-0.94)	<0.01	0.95 (0.71-1.25)	0.70	
Parity					
0	1.00		1.00		
1	0.73 (0.66-0.80)	<0.001	0.76 (0.64-0.91)	<0.01	0.46
2	0.81 (0.72-0.92)	<0.01	0.84 (0.66-1.06)	0.15	
3	0.10 (0.92-1.31)	0.31	0.88 (0.62-1.24)	0.45	
4	0.98 (0.71-1.36)	0.93	0.66 (0.35-1.23)	0.19	
5+	10.68 (9.52-11.99)	<0.001	1.37 (0.84-2.24)	0.21	
Deprivation					
1=Deprived	1.49 (1.31-1.70)	<0.001	1.15 (0.89-1.49)	0.27	0.96
2	1.44 (1.26-1.65)	<0.001	1.13 (0.87-1.46)	0.35	
3	1.20 (1.04-1.39)	0.01	1.09 (0.84-1.42)	0.51	
4	1.17 (1.01-1.36)	0.04	1.22 (0.94-1.59)	0.14	
5=Affluent	1.00		1.00		
Eclampsia					
None	1.00		1.00		
Preexisting HTN	0.37 (0.20-0.69)	<0.01	0.39 (0.15-1.01)	0.05	
Pre- & Eclampsia	0.91 (0.73-1.13)	0.38	0.43 (0.27-0.69)	<0.001	
Smoking status					
Never smoker	1.00		1.00		
Current smoker	1.52 (1.39-1.67)	<0.001	0.81 (0.68-0.97)	0.02	
Former smoker	0.85 (0.72-1.01)	0.06	0.71 (0.54-0.93)	0.01	
Sex					
Female	1.00		1.00		
Male	1.25 (1.15-1.35)	<0.001	1.20 (1.04-1.40)	0.01	
Apgar score					
0-3	280.4 (254.7-308.7)	<0.001	94.91 (76.70-117.45)	<0.001	<0.001
4-6	49.8 (44.1-56.1)	<0.001	16.75 (13.09-21.42)	<0.001	
7-10	1.00		1.00		
Gestation/ weeks					
<28	589.6 (532.3-653.2)	<0.001	17.22 (9.87-30.03)	<0.001	<0.001
28-<32	52.66 (45.8-60.5)	<0.001	2.96 (1.80-4.88)	<0.001	
32-<37	9.3 (8.2-10.4)	<0.001	2.56 (1.88-3.50)	<0.001	
37-<42	1.00		1.00		
>=42	0.95 (0.7-1.4)	0.80	1.06 (0.62-1.80)	0.84	
Birthweight/ g					
<1,500	180.8 (164.4-198.9)	<0.001	4.83 (2.87-8.14)	<0.001	<0.001
1,500-<2,500	9.7 (8.6-10.9)	<0.001	2.45 (1.77-3.37)	<0.001	
2,500-4,000	1.00		1.00		
>4,000	0.80 (0.64-0.99)	0.04	0.65 (0.46-0.91)	0.01	
Previous neonatal death					
0	1.00		1.00		
1	4.81 (3.54-6.54)	<0.001	2.48 (1.36-4.51)	<0.01	<0.001
2	6.74 (2.79-16.30)	<0.001	3.60 (0.72-18.07)	0.12	
Previous stillbirth	2.12 (1.46-3.09)	<0.001	0.71 (0.36-1.38)	0.31	
Multivariable model adjusted for deprivation, maternal age, parity, sex, marital status, Apgar at fifth minute, birthweight and smoking status at booking.					
HTN: Hypertension					

Table 5.3.5 shows the factors associated with neonatal mortality in Scotland using multiple imputations by chained equations. The results of the univariate MI analyses are fairly similar to those of the complete cases in Table 5.3.4. The results from the multivariable MI analyses showed that single mothers were 24% (14%-33%) less likely to experience neonatal death compared with married mothers. Multivariable MI analyses showed significant associations between the neonatal factors and neonatal mortality. Boys were 14% more likely to die in the neonatal period compared to girls (OR 1.14, 95% CI 1.03-1.26, p=0.01) and the risk of neonatal death increased with decreasing birth weight (p<0.001), Apgar score at 5 minutes (p<0.001) and gestation (p<0.001). Babies who weighed less than 1,500g at birth were approximately four times more likely to die, and those who weighed between 1,500g and 2,500g were about twice as likely to die, compared to those who weighed between 2,500 and 4,000g. There was no statistical difference in the risk of death between babies who weighed more than 4,000g and those between 2,500g and 4,000g. The greatest risk for neonatal death was for babies who scored less than 3 on the five-minute Apgar score. They were over 70 times more likely to die compared to those who scored above 7. Babies who were born at less than 37 weeks gestation were more likely to die in the neonatal period compared to those who were born between 37 and 42 weeks. There was no significant difference in the risk of death between babies who were born after 42 weeks and those who were born between 37 and 42 weeks.

Counter intuitively, mothers who ever smoked, current smokers (OR 0.87, 95% CI 0.77-0.99) and former smokers (OR 0.78, 95% CI 0.63-0.97), were less likely to experience neonatal death compared to mothers who never smoked. Also, mothers with pre-existing hypertensive disorders (OR 0.37, 95% CI 0.17-0.78), pre-eclampsia or eclampsia (OR 0.37, 95% CI 0.28-0.50) were 63% less likely each to experience neonatal death compared to mothers without any of these medical conditions and the risk of neonatal death increased by the number of previous neonatal deaths (<0.01). After excluding Apgar score, birthweight and gestation from the multivariable model, because they were likely to be on the causal path between smoking and neonatal mortality (discussed in Section 5.5.3), smokers were significantly more likely to experience neonatal death and former smokers were less likely to experience neonatal death. The risk of neonatal mortality increased with number of previous neonatal deaths.

Table 5.3.5: Logistic regression analyses of factors associated with neonatal mortality in Scotland using multiple imputations by chained equations

	Univariate		Multivariable (N=1,278,382)		
	OR (95% CI)	p-value	OR (95% CI)	p-value	p-trend
Mother's age					
<20	1.39 (1.22-1.59)	<0.001	1.00 (0.83-1.20)	0.99	0.95
20-29	1.00		1.00		
30-39	1.00 (0.92-1.10)	0.99	0.93 (0.83-1.04)	0.18	
40+	1.35 (1.7-1.71)	0.01	1.02 (0.74-1.39)	0.92	
Marital status					
Single	1.01 (0.92-1.11)	0.83	0.76 (0.67-0.86)	<0.001	
Married	1.00		1.00		
Widowed	1.75 (0.33-9.26)	0.50	0.48 (0.06-3.98)	0.49	
Separate/Divorce	2.35 (1.59-3.45)	<0.001	1.29 (0.79-2.12)	0.31	
Other	1.26 (1.06-1.50)	0.01	0.95 (0.77-1.17)	0.62	
Parity					
0	1.00		1.00		
1	0.73 (0.66-0.80)	<0.001	0.91 (0.81-1.02)	0.11	0.21
2	0.81 (0.72-0.92)	0.001	0.87 (0.74-1.03)	0.11	
3	1.10 (0.92-1.31)	0.31	0.85 (0.67-1.08)	0.18	
4	0.98 (0.71-1.36)	0.93	0.68 (0.45-1.02)	0.07	
5	10.68 (9.52-11.99)	<0.001	1.13 (0.78-1.63)	0.52	
Deprivation					
1=Deprived	1.59 (1.39-1.82)	<0.001	0.99 (0.84-1.18)	0.93	0.55
2	1.48 (1.28-1.70)	<0.001	1.06 (0.89-1.25)	0.53	
3	1.22 (1.06-1.41)	0.01	0.96 (0.81-1.15)	0.69	
4	1.18 (1.02-1.37)	0.03	1.05 (0.88-1.25)	0.60	
5=Affluent	1.00		1.00		
Eclampsia					
Preexisting HTN	0.37 (0.20-0.69)	<0.01	0.37 (0.17-0.78)	0.01	
Pre- & Eclampsia	0.91 (0.73-1.13)	0.38	0.37 (0.28-0.50)	<0.001	
None	1.00		1.00		
Smoking status					
Never smoker	1.00		1.00		
Current smoker	1.61 (1.47-1.76)	<0.001	0.87 (0.77-0.99)	0.04	
Former smoker	0.85 (0.71-1.03)	0.09	0.78 (0.63-0.97)	0.03	
Sex					
Female	1.00		1.00		
Male	1.25 (1.16-1.35)	<0.001	1.14 (1.03-1.26)	0.01	
Apgar score					
0-3	318.06 (287.63-351.69)	<0.001	73.47 (63.18-85.35)	<0.001	<0.001
4-6	53.51 (47.68-60.06)	<0.001	13.94 (11.77-16.50)	<0.001	
7-10	1.00		1.00		
Gestation / weeks					
<28	653.49 (590.69-722.98)	<0.001	22.50 (15.58-32.50)	<0.001	<0.001
28-<32	61.00 (53.60-69.42)	<0.001	4.00 (2.87-5.58)	<0.001	
32-<37	9.82 (8.68-11.11)	<0.001	3.08 (2.49-3.79)	<0.001	
37-<42	1.00		1.00		
>=42	0.90 (0.62-1.32)	0.59	0.94 (0.65-1.38)	0.77	
Birthweight/ g					
<1,500	208.91 (190.74-228.80)	<0.001	4.23(2.99-6.00)	<0.001	<0.001
1,500-<2,500	10.20 (9.05-11.48)	<0.001	2.64 (2.12-3.29)	<0.001	
2,500-4,000	1.00		1.00		
>4,000	0.76 (0.61-0.94)	0.01	0.84 (0.67-1.04)	0.11	
Previous neonatal death					
0	1.00		1.00		
1	7.63 (5.92-9.82)	<0.001	1.93 (1.18-3.16)	0.01	<0.01
2	5.53 (2.29-13.36)	<0.001	3.64 (0.97-13.64)	0.06	
Previous stillbirth	3.29 (2.29-4.73)	<0.001	0.74 (0.44-1.25)	0.26	

Multivariable model adjusted for deprivation, maternal age, parity, sex, marital status, Apgar at fifth minute, birthweight and smoking status at booking

5.3.4 Distribution and causes of neonatal deaths in Scotland

There was a total of 2,783 neonatal deaths during the study period. Almost all (99.5%) of these deaths occurred in the early neonatal period (0-6 days), and the majority (61%) of these occurred on the day of birth. Only 12 (0.4%) babies died after the first week of birth. The major causes of neonatal deaths in Scotland, were congenital malformations (29%), intrapartum hypoxia and birth asphyxia (24%), and prematurity and low birth weight (15%). Figure 5.3.3 shows the distribution of neonatal deaths by the age at death.

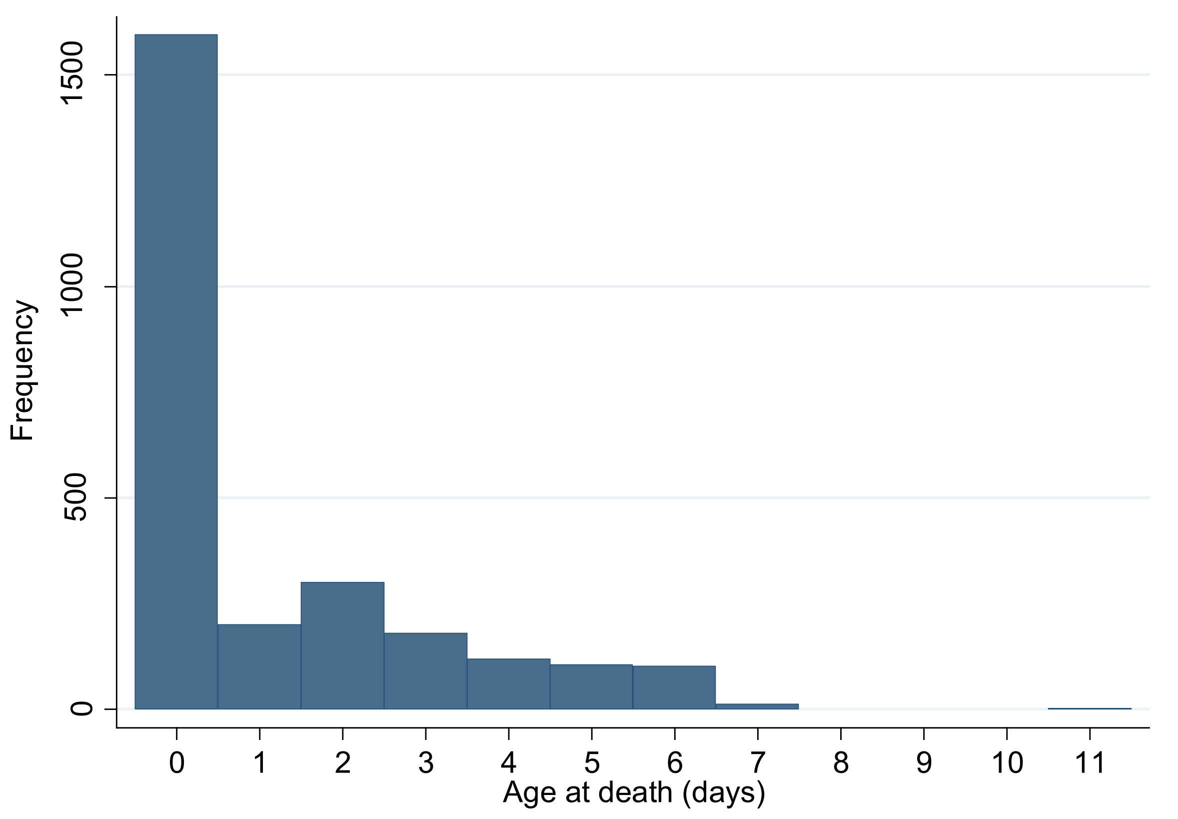


Fig 5.3.3 Distribution of neonatal mortality in Scotland by age at death

Figure 5.3.3 shows the distribution of neonatal deaths in Scotland over the study period. The histogram shows that the majority of babies died on the first day of birth and no baby between the 12th and 28th day.

Table 5.3.6 shows the causes of neonatal death, according to early (0-6 days) and late (7-27 days) neonatal deaths. Among babies who died on the day of birth (day 0), the leading causes of death, contributing approximately 90% of the total, were as follows: congenital conditions (n=380, 29.6%), prematurity and low birth weight (n=319, 24.9%), intrapartum hypoxia/ birth asphyxia (n=239, 18.7%) and maternal complications (n=204, 15.9%).

Table 5.3.6 Neonatal deaths by causes and age at death in Scotland 1992-2015

	Day of death		
	0-6 days	**7-27 days**	**Total**
	n=2,597	**n=12**	**N=2,783**
Cause of death			
Congenital conditions	756	2	758 (29.1)
Intrapartum hypoxia/ birth asphyxia	611	3	614 (23.5)
Prematurity and low birth weight	399	3	402 (15.4)
Maternal complications	302	0	302 (11.6)
Haemorrhagic conditions	139	1	140 (5.4)
Other perinatal conditions	98	0	98 (3.8)
Perinatal infections	88	0	88 (3.4)
Temperature control	35	0	35 (1.3)
Digestive/Intestinal tract disorders	33	1	34 (1.3)
Others	30	1	31 (1.2)
Sudden infant death syndrome	29	1	30 (1.1)
Birth trauma	19	0	19 (0.7)
Neoplasm	17	0	17 (0.7)
Endocrine, nutritional and metabolic	16	0	16 (0.6)
Anaemia & immunodeficiency	15	0	15 (0.6)
Neurological disorders	6	0	6 (0.2)
Respiratory disorders	4	0	4 (0.2)
Missing	-	-	174
Other perinatal conditions include convulsions and other cerebral disturbances			
Maternal complications include complications of the placenta or membranes			
Other conditions include urinary disorders,			

Table 5.3.7 shows the temporal trends in the number of babies who died by the cause of death and the cause-specific NMR. Overall, the NMR for each major cause of death fell over the study period, with the largest decline seen in congenital malformations (80% decline) from 1.02 in 1992 to 0.2 in 2015.

Table 5.3.7 Trends in NMR by major causes of death

	Congenital conditions	Intrapartum hypoxia/ asphyxia	Prematurity and LBW	Maternal complica tions	Haemorrha gic conditions	Perinatal infection
	n(CSNMR)	n(CSNMR)	n(CSNMR)	n(CSNMR)	n(CSNMR)	n(CSNMR)
	n=758	n=614	n=402	n=302	n=140	n=88
Year						
1992	64 (1.02)	57 (0.91)	21 (0.34)	22 (0.35)	8 (0.13)	5 (0.08)
1993	70 (1.15)	52 (0.85)	10 (0.16)	16 (0.26)	6 (0.10)	4 (0.07)
1994	36 (0.61)	41 (0.69)	16 (0.27)	13 (0.22)	10 (0.17)	3 (0.05)
1995	46 (0.80)	42 (0.73)	13 (0.23)	11 (0.19)	5 (0.09)	3 (0.05)
1996	45 (0.81)	45 (0.81)	21 (0.38)	8 (0.14)	3 (0.05)	4 (0.07)
1997	40 (0.70)	37 (0.65)	14 (0.25)	6 (0.11)	7 (0.12)	4 (0.07)
1998	25 (0.45)	33 (0.60)	22 (0.40)	8 (0.15)	7 (0.13)	5 (0.09)
1999	36 (0.68)	26 (0.49)	16 (0.30)	7 (0.13)	5 (0.10)	5 (0.10)
2000	28 (0.55)	33 (0.65)	23 (0.45)	13 (0.26)	7 (0.14)	3 (0.06)
2001	31 (0.62)	23 (0.46)	19 (0.38)	15 (0.30)	9 (0.18)	7 (0.14)
2002	25 (0.51)	21 (0.43)	10 (0.20)	11 (0.23)	7 (0.14)	6 (0.12)
2003	26 (0.52)	18 (0.36)	18 (0.36)	9 (0.18)	4 (0.08)	2 (0.04)
2004	16 (0.31)	27 (0.52)	20 (0.39)	12 (0.23)	6 (0.12)	6 (0.12)
2005	32 (0.62)	23 (0.45)	17 (0.33)	13 (0.25)	9 (0.18)	2 (0.04)
2006	26 (0.50)	15 (0.29)	16 (0.31)	16 (0.31)	7 (0.14)	4 (0.08)
2007	33 (0.60)	19 (0.35)	21 (0.38)	14 (0.26)	8 (0.15)	4 (0.07)
2008	26 (0.46)	10 (0.18)	24 (0.42)	8 (0.14)	5 (0.09)	3 (0.05)
2009	31 (0.55)	12 (0.21)	15 (0.27)	17 (0.30)	5 (0.09)	3 (0.05)
2010	24 (0.43)	21 (0.38)	18 (0.32)	11 (0.20)	3 (0.05)	3 (0.05)
2011	22 (0.40)	14 (0.25)	16 (0.29)	13 (0.23)	7 (0.13)	1 (0.02)
2012	22 (0.40)	9 (0.16)	16 (0.29)	19 (0.34)	4 (0.07)	6 (0.11)
2013	20 (0.38)	15 (0.28)	11 (0.21)	12 (0.23)	3 (0.06)	3 (0.06)
2014	29 (0.55)	13 (0.25)	19 (0.36)	21 (0.40)	4 (0.08)	1 (0.02)
2015	5 (0.20)	8 (0.32)	6 (0.24)	7 (0.28)	1 (0.04)	1 (0.04)

CNMR: Cause specific neonatal mortality rate, per 1,000 live births

$$\mathrm{CSNMR} = \frac{\text{cause specific number of deaths}}{\text{Total number of live births}} \times 1{,}000$$

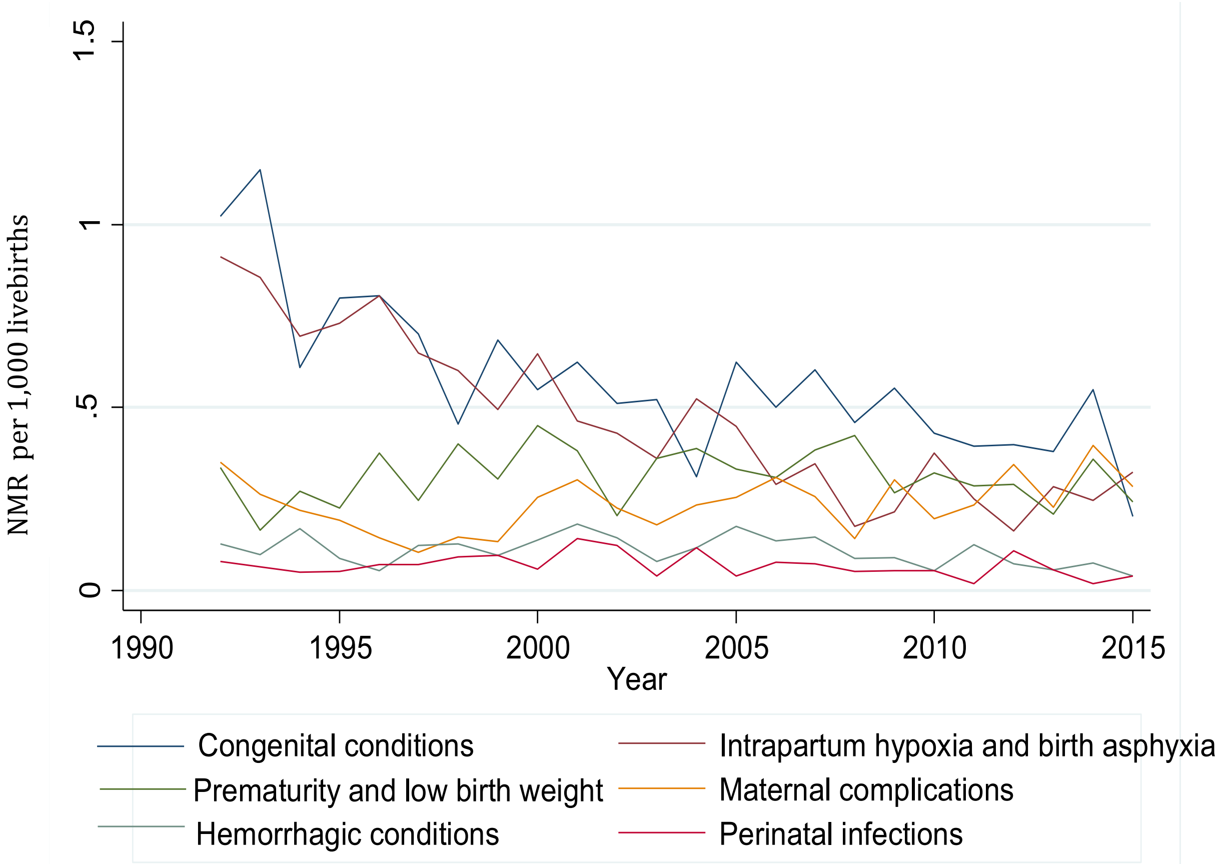


Fig 5.3.4 Trends in cause-specific NMR in Scotland, 1992-2015

Figure 5.3.4 shows the trends in NMR in Scotland according to the major causes of death. The line graph shows a large overlap in the cause-specific NMR (CSNMR) from 1992-2015.

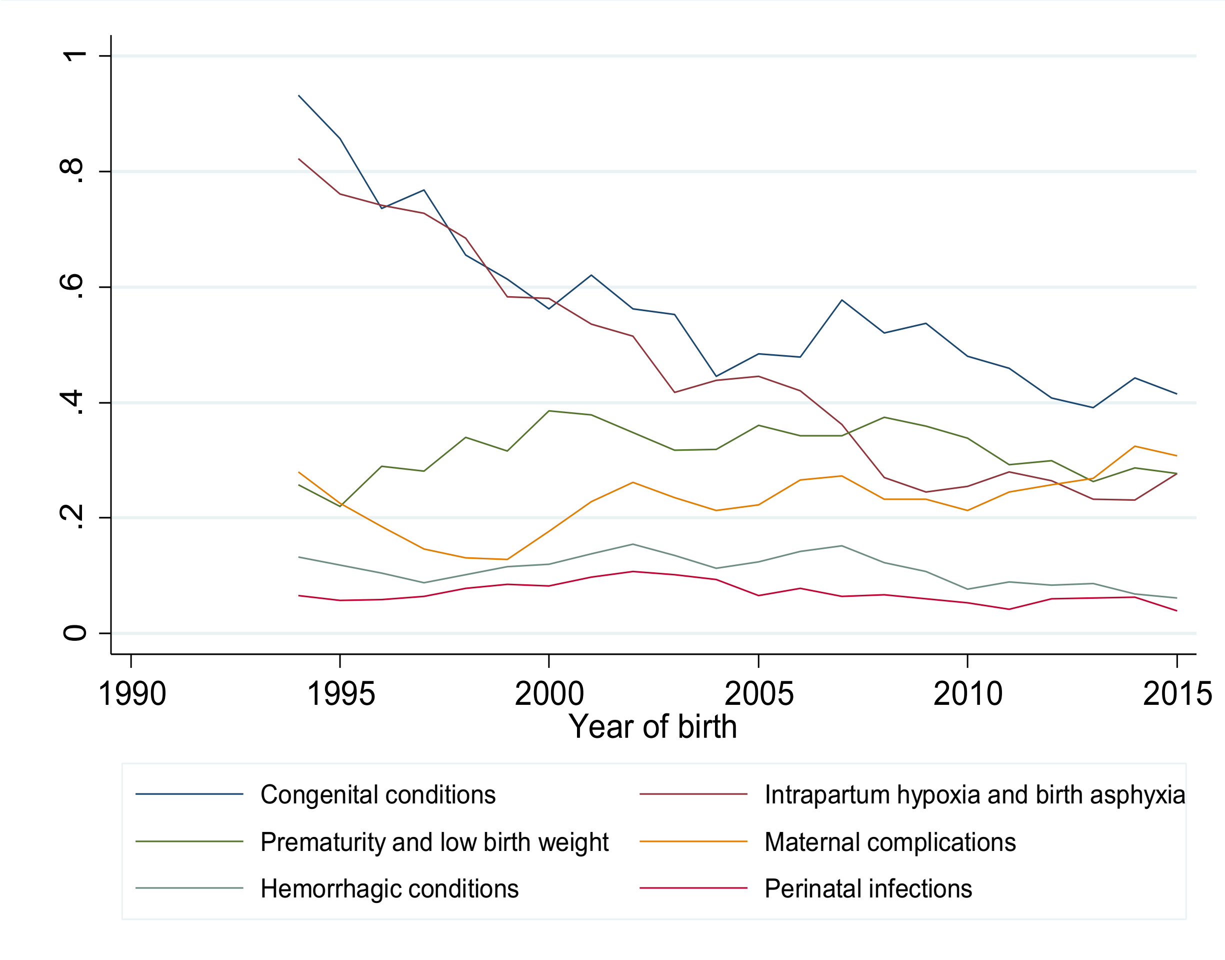


Fig 5.3.5 Three-year moving average cause-specific neonatal mortality rate in Scotland, 1992-2015

The line graph in Figure 5.3.5 shows a three-year moving average CSNMR for the major causes of death in Scotland, 1992-2015. The graph shows large falls in deaths due to congenital malformations and intrapartum hypoxia. The three-year average CSNMRs for infections remained fairly constant but at a very low level. Congenital conditions had consistently higher average CSNMRs for the most part of the study period, and deaths due to perinatal infections had the lowest CSNMRs throughout the study period.

Table 5.3.8 presents the causes of neonatal death profile according to the significant risk factors shown in the multivariable logistic regressions. The table shows significant differences in the causes of neonatal death by marital status, parity, smoking status of mother, Apgar score, gestation and birthweight. Babies born to married mothers were more likely to die of congenital malformations and those born to single mothers were more likely to die of prematurity and low birth weight. Babies born to nulliparous women were more likely to die of haemorrhagic conditions and those born to grand multiparous mothers were more likely to die of prematurity and low birth weight. Babies born to never smokers were more likely to die of infections and those born to smokers and former smokers were more likely to die of maternal complications. Babies with a five minute Apgar score not more than three were more likely to die of maternal complications and those who scored above 7 were more likely to die of congenital malformations. Babies born before 28 weeks of completed pregnancy, and those who weighed less than 1.5Kg at birth were more likely to die of prematurity and low birth weight. There was no statistically significant difference in the causes of neonatal death between boys and girls, or according to whether mothers had experienced a previous neonatal death or stillbirth or had eclampsia or pre-eclampsia and those who did not.

Table 5.3.8: Cause of death profile for neonatal deaths according to risk factors

	Congenital conditions	Hypoxia/ birth asphyxia	Prematurity and low birth weight	Maternal complica tions	Haemorrh agic conditions	Perinatal infection	P-value
	n=758	**n=614**	**n=402**	**n=302**	**n=140**	**n=88**	
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	
Marital status							
Single	178 (31)	170 (36)	111 (44)	72 (35)	43 (43)	24 (41)	<0.01
Married	335 (61)	255 (54)	108 (43)	105 (52)	47 (47)	28 (48)	
Widowed	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	
Separated/Divo rce	9 (2)	4 (1)	4 (2)	3 (1)	1 (1)	1 (2)	
Other	39 (7)	44 (9)	28 (11)	23 (11)	10 (10)	5 (9)	
Parity							
0	313 (41)	302 (49)	176 (44)	115 (38)	72 (51)	35 (40)	<0.001
1	232 (31)	153 (25)	76 (19)	62 (21)	27 (19)	16 (18)	
2	96 (13)	58 (9)	24 (6)	43 (14)	19 (14)	12 (14)	
3	22 (3)	31 (5)	19 (5)	22 (7)	7 (5)	2 (2)	
4	10 (1)	7 (1)	4 (1)	7 (2)	2 (1)	2 (2)	
5	85 (11)	63 (10)	103 (26)	53 (18)	13 (9)	21 (24)	
Eclampsia							
None	744 (98)	589 (96)	388 (97)	293 (97)	132 (94)	86 (98)	
HTN	1 (0)	3 (0)	1 (0)	1 (0)	1 (1)	0 (0)	0.35
Pre- & Eclampsia	13 (2)	22 (4)	13 (3)	8 (3)	7 (5)	2 (2)	
Smoking status							
Never smoker	372 (65)	252 (54)	130 (51)	100 (47)	54 (55)	40 (69)	<0.001
Current smoker	176 (31)	170 (37)	106 (41)	92 (43)	38 (38)	13 (22)	
Former smoker	27 (5)	41 (9)	21 (8)	21 (10)	7 (7)	5 (9)	
Sex							
Female	294 (43)	234 (41)	135 (44)	118 (46)	49 (62)	34 (47)	0.67
Male	385 (57)	330 (59)	175 (56)	140 (54)	80 (38)	38 (53)	
Apgar score							
0-3	226 (35)	228 (45)	198 (74)	178 (77)	37 (32)	24 (74)	<0.001
4-6	145 (23)	107 (21)	38 (14)	23 (10)	30 (26)	13 (14)	
7-10	272 (42)	175 (34)	32 (12)	30 (13)	47 (41)	26 (13)	
Gestation / weeks							
<28	66 (10)	286 (51)	295 (97)	118 (46)	77 (60)	35 (49)	<0.001
28-<32	71 (10)	70 (12)	5 (2)	45 (18)	18 (14)	6 (8)	
32-<37	220 (32)	45 (8)	2 (1)	40 (16)	14 (11)	10 (14)	
37-<42	323 (47)	147 (26)	2 (1)	53 (21)	20 (16)	21 (29)	
>=42	6 (1)	13 (2)	0 (0)	1 (0)	0 (0)	0 (0)	
Birthweight/ g							
<1,500	140 (21)	348 (63)	263 (99)	136 (55)	92 (72)	35 (51)	<0.001
1,500-<2,500	225 (34)	45 (8)	2 (1)	46 (19)	10 (8)	5 (7)	
2,500-4,000	283 (42)	142 (26)	2 (1)	53 (22)	24 (19)	26 (38)	
>4,000	22 (3)	21 (4)	0 (0)	11 (4)	2 (2)	2 (3)	
Previous neonatal death							
0	453 (99)	347 (97)	238 (96)	189 (97)	96 (94)	54 (96)	0.32
1	6 (1)	11 (3)	10 (4)	4 (2)	6 (6)	1 (2)	
2	0 (0)	1 (0)	0 (0)	1 (1)	0 (0)	1 (2)	
Previous stillbirth							
No	456 (99)	354 (99)	242 (98)	192 (9)	97 (95)	55 (98)	0.45
Yes	3 (1)	5 (1)	6 (2)	2 (1)	5 (5)	1 (2)	

HTN: Hypertension

5.4 Summary of key findings

The overall NMR in Scotland for 1992-2015 was 2.2 for singleton births, with a steady decline of over 60% from 3.2 in 1992 to 1.2 in 2015. Very preterm babies, those with very low birthweight and very low Apgar scores had the highest NMR and the greatest risk of neonatal death. Almost all the neonatal deaths, 99.5%, occurred within one week of birth and the major causes of death over the period were congenital malformations (29%), intrapartum hypoxia or birth asphyxia (24%), prematurity and low birthweight (15%) and maternal complications (12%). Results from the multivariable logistic regression analyses of both complete and imputed cases showed that babies who were more likely to die in the neonatal period were: boys, those born before 37 weeks of completed pregnancy, babies with an Apgar score less than 7 at five minutes, and those who weighed less than 2.5kg. Married mothers, those who had experienced a previous neonatal death and those who smoked were more likely to experience neonatal death.

5.5 Discussion

5.5.1 NMR

The NMR of 2.2 for singleton births reported in this study is comparable to those reported in other parts of the UK (261) and other developed countries (262). The 2011 Scottish Perinatal and Infant Mortality and Morbidity Report (SPIMMR) (260) reported that the overall NMR in Scotland, including multiple births, during the same period was 2.7. Babies delivered breech had the highest NMR, and those born to mothers with history of previous neonatal mortality, more than five children, low birthweight, low gestation age, and low Apgar score also had very high NMR (263-265). This study confirmed that NMR in Scotland has fallen over time (13).

5.5.2 Death profile for neonatal deaths

As shown in previous studies, over 99% of neonatal deaths in Scotland occurred within the first week of birth, and 61% of these occurred on the first day (5). This represents early and late NMRs of 2.2 and 0.0009 (or 9 deaths per 1,000,000 livebirths) respectively. The leading causes of neonatal mortality were congenital malformations (29.1%), followed by hypoxia or birth asphyxia (23.5%), prematurity (15.4%) and maternal complications (11.6%). Infections were responsible for only 3.4% of all neonatal deaths. Similar results have been reported in England (261) and other developed countries (266). Given that two-thirds of late neonatal deaths in Scotland were caused by prematurity, hypoxia and congenital malformations, interventions targeted at early neonatal deaths should also influence late neonatal deaths (267, 268).

Advances in neonatal care have led to improvement in the survival of premature babies. However, the rate of preterm birth is increasing in the UK and internationally (30, 68, 269). This implies that unless measures are taken to further improve the care of preterm babies, especially the extremely preterm, deaths due to prematurity will increase (15, 270). Each year, direct complications of preterm births contribute to one million deaths globally and it is a risk factor for half of all neonatal deaths (68). The epidemiology of preterm birth (68, 270, 271). and interventions to reduce associated morbidity and mortality have been published (268). In the UK, such guidelines are available at www.nice.org.uk/guidance/ng25

Birth asphyxia, or intrapartum hypoxia, is the second leading cause of neonatal mortality in the world and it contributes a third of the world's 3.2 million stillbirths (272). It refers to a condition of marked impairment of gaseous exchange, which if prolonged, leads to hypoxemia, hypercapnia and metabolic acidosis (259, 273). According to Lawn et al.,(246), the term 'birth asphyxia', as defined by the WHO (273), is imprecise because although it suggests the need for resuscitation, it does not specify the aetiology. They argue that since babies may not breathe due to other reasons like prematurity, a more specific term should be applied. They recommend using birth asphyxia only when there is evidence of acute intrapartum causation or else the term "neonatal deaths associated with acute intrapartum events" should be used. This is cumbersome and so for the purpose of this thesis and also to allow comparison to the Ghanaian data later on, I maintain the term birth asphyxia, or intrapartum hypoxia, as used in the NRS data and other published literature (14, 59). The causes of asphyxia vary but prolonged labour, prematurity and placental or umbilical cord problems are well known examples. In the current study, 71% of the babies who died of asphyxia were preterm (<37 weeks) and most of them (71%) were extremely preterm babies (<28 weeks). Previous studies in Scotland found that being delivered outside the normal working hours (Monday to Friday, 09:00 to 17:00) (50) and advanced maternal age (274) increased the risk of death due to anoxia. The basic management of asphyxia involves immediate resuscitation with mechanical ventilation or induced hypothermia being employed if required: these are routinely available in Scotland.

Congenital malformations may be more common in conditions known to be genetic or chromosomal. Other genetic and nutritional factors, maternal demographics such as socioeconomic status and age, infectious and environmental factors have been implicated (275). The most common congenital anomalies are heart and neural tube defects and Down syndrome. Current recommendations include maternal immunisation against rubella virus, adequate intake of folic acid and iodine and adequate antenatal care to ensure early detection (276-278). The sixty-third World Health Assembly resolution on birth defects encourages member states to raise awareness among stakeholders, regulate use of chemicals in water, air and soil, promote coverage of preventive activities, and establish national programmes for surveillance, prevention and care of babies with congenital defects (279).

5.5.3 Risk factors for neonatal mortality

Babies with low birthweight (<2,500 grams), low gestational age (<37 weeks), low Apgar score and boys were found to be more likely to die in the neonatal period. Low birth weight and low gestational age are well established as strong predictors of neonatal mortality (5, 280). Low birthweight is a blunt measure as it may be due to preterm delivery or intra-uterine growth restriction. Previously, low birthweight or low gestational age was used to diagnose prematurity (57). However, because they could be conceptually and aetiologically distinct, in recent times, low gestational age is used more to denote prematurity (that is born too early) and low birthweight for a baby that is born too small (281). Babies who are small for gestational age (SGA) have also been found to be at risk for neonatal mortality (282). The causes of preterm birth and risk factors for low birth weight have been published elsewhere (271, 283, 284).

The Apgar score by definition includes a measure of a baby’s respiration, heart rate, colour, reflexes and muscle tone. The association between low Apgar scores and neonatal mortality has been long established, and some studies have found it to be associated with birth asphyxia and its neurological complications (249, 285, 286). Although not diagnostic of an asphyxia, a low Apgar score or a change in score is a useful indicator of the need for resuscitation (259).

Boys have long been known to be at higher risk of neonatal death than girls, what has become known as the 'male disadvantage' (136-139). My findings show that boys continue to be at increased risk of neonatal death than girls despite technological advances in neonatal care. The biological mechanism underlying the excess mortality among boys is not fully understood and some authors suggest a delay in lung maturation (140, 141), a higher rate of SGA among boys (142) or genetics (287). In the current study, there were more male deaths due to congenital malformations and hypoxia, but the differences were not statistically significant.

The data showed that married mothers and those with a history of a previous neonatal mortality had a significantly higher risk of neonatal mortality. I could not find any published study on the association between a previous neonatal mortality and another neonatal mortality, but it is may be due to common non-attenuated risks associated with previous neonatal death. It may be important for clinicians to consider a previous neonatal death as a risk for another neonatal death in order to monitor the current pregnancy more closely.

The finding that babies of never smokers are at higher risk of neonatal death than current and former smokers seem contrary to historic evidence which suggested a causal relationship between maternal smoking and neonatal mortality, mediated by low birthweight (288, 289). The controversy that arose after such 'causal claims' is well documented (290, 291) and more recent studies suggest that a direct association between smoking and neonatal mortality is weak (280). It has also been suggested that the causal relationship between smoking and neonatal mortality is mediated by reduced fetal growth and shorter gestation (280, 290, 292, 293). When Apgar score, birthweight and gestation were removed from the multivariable regression model, it was shown that babies of smokers had a significantly higher risk of neonatal death compared to those of never smokers and babies of former smokers had a significant lower risk of death. This suggests that the previous model including birthweight, gestation and Apgar was over-adjusted (294). It is recommended that public health education and smoking cessation programmes targeted at pregnant women should be intensified.

Similarly, a multivariable regression model with gestation, birthweight and Apgar score suggested that pre-eclampsia or maternal hypertensive disorders were protective of neonatal mortality. This was unexpected and is contrary to previous studies which show significant association between hypertensive disorders in pregnancy and adverse fetal and neonatal outcomes (295, 296). These studies show that the excess mortality among mothers with pre-eclampsia was attributable to preterm birth (297). When gestation and its proxy measurements were excluded from the multivariable model (298), the association between hypertensive disorders and neonatal mortality was not statistically significant. Late preterm delivery is common among mothers with pre-eclampsia as a consequence of elective caesarean section or induction of labour (299), and elective caesarean section has been associated with reduced risk of neonatal mortality among high risk pregnancies (300, 301). In the UK, management of pre-eclampsia and other hypertensive disorders in pregnancy involve close monitoring of mother and fetus by a team of clinicians and consultant obstetric staff and adequate management of the preterm baby (302). Could it then be possible that adequate monitoring and management of babies and mothers with hypertensive disorders may have offset the detrimental consequences hypertensive related diseases in pregnancy? This thesis did not demonstrate any significant difference in the cause of death profile between mothers according to hypertensive disorders or previous neonatal mortality.

5.5.4 Strengths and Limitations

This study involved a large sample of more than one million births over a period of more than 30 years. This includes nearly all singleton births in Scotland over the period and thus minimises selection bias. The findings of this study can therefore be reasonably extrapolated to other countries with similar demographic, cultural and healthcare characteristics. This study draws data from a linkage between two sources allowing for completeness of data, and availability of many potential confounding variables. The data are subject to regular quality checks and some of the variables included in this study were found to be 100% accurate. Although the data contained some missing variables, the fact that estimates from the imputed models were similar to those of the complete cases suggest that the missing data did not introduce bias. The last study published on neonatal mortality among singletons in Scotland was based on data which was over 10 years old (303), and was restricted to term singletons with cephalic presentation excluding those who died of congenital malformations. There was the need to update the study to observe changes in trends, and also include a wider population to allow investigation of other risk factors.

The aim of this chapter was to conduct analyses which are comparable to the Ghanaian data (Chapter 4). There is good justification for this: identifying similarities or differences in risk factors for neonatal death between the two countries will help to identify interventions which could have contributed to these. It is only by such comparisons that improvements in newborn health outcomes can be achieved (21). I, thus, ensured that the Scottish and the Ghanaian analyses were comparable as much as possible. Given that the Ghanaian analyses were stratified by place of delivery and all births included in the Scottish analyses were delivered in hospitals, no further subgroup analyses were explored. The prevalence of non-white ethnicity is low in Scotland and ethnicity is not well recorded in the SMR data, therefore I did not adjust for ethnic group in the multivariable model. This could confound my findings, as will residual confounding given the observational nature of this study.

Chapter 6 Questionnaire survey of maternity care providers in Ghana

6.1 Introduction

It is common for epidemiologists investigating neonatal mortality to analyse large quantitative datasets on mothers and their babies. As seen in Chapters 4 and 5 of this thesis, the value of such analyses in determining the NMR and factors associated with newborn deaths cannot be overemphasised. Any efforts to improve newborn health and practice will, nevertheless, require a multiple stakeholder approach, particularly the involvement of maternity care providers, whose voices, unfortunately, are largely missing from the discourse (88). This chapter, therefore, describes the methods and results of a questionnaire survey of doctors, midwives and traditional birth attendants (TBAs) in the three health and demographic surveillance areas in Ghana to provide their perspectives on the factors influencing neonatal mortality in Ghana. The aims of the survey were to:

i. describe the characteristics of maternity care providers and types of maternity services in Ghana
ii. describe the birth practices of the various maternity care providers

This survey represents the 1ºQUAN phase of the overall multilevel mixed methods design which is already described in Chapter 3 of this thesis.

6.2 Methods

6.2.1 Sampling method

A multilevel mixed method sampling approach was used to select maternity care providers included in this survey. The aim of the sampling technique was to achieve both maximum variation and representativeness. Firstly, a stratified purposeful sampling method was used to select delivery settings included in the survey. Each of the three surveillance areas covers two administrative districts. Delivery settings in these surveillance areas were, therefore, stratified by district and type of service setting: hospital, clinic and home delivery (3 surveillance areas × 2 districts × 3 types of settings). Service settings with high numbers of deliveries in the preceding half year (January-June 2015) were purposefully selected from each district. Following that, maternity care providers in the selected delivery facilities were purposively selected. When there was more than one maternity care provider, midwives or doctors were selected if they had practised for at least 2 years. Details are summarised in Table 6.1.

Stratified purposeful sampling is a well-known and widely used mixed method sampling technique (207, 304). Teddlie and Yu (203) in their highly cited article published in the *Journal of Mixed Methods Research* described the stratified purposive sampling technique as one of the core forms of mixed methods sampling strategy, and examples of its usage abound in social science texts (305-307). Although from a probability standpoint, the sample from a stratified purposeful technique may not be 'statistically representative' (308), from a nonprobability standpoint, it is 'informationally representative'. The aim of the survey to describe birth practices implied that a purposefully selected sample of the most informative care providers was selected across each type of delivery setting. The lack of a register for maternity care providers in Ghana also meant a simple random sample would be impractical. A previous survey of maternity care providers in Ghana used a multilevel mixed methods sampling technique (202).

6.2.2 Selection of sample size

The objective of the sample size calculation was to select the minimum number of each care provider cadre that would provide precise information regarding their birth practices. According to Sandelowski (304), where there are four or more strata to select subjects from, a researcher may select 1-2 cases from each strata (Table 6.1B and 6.1C) to achieve maximum variation. Based on the statistics available as at July 2015 (Table 6.1A), it was determined that 67 maternity care providers would be selected for the survey (Table 6.1D). Previous studies of maternity care providers in Ghana have had sample sizes of less than 70 (202, 309). Details of the numbers of maternity care providers by region (sampling frame) and the type that I intended to recruit (sample) are shown in Table 6.1.

Table 6.1: Distribution of health workers and recruitment strategy

A. Distribution of numbers of staff in July 2015*				
Surveillance area	Doctors	Midwives	TBA**	Total
Dodowa	3	40	27	
Kintampo	5	22	36	
Navrongo	3	58	209***	
Total	11	106	272	389

*Data collated from the district public health nurses in respective regions
** Data on TBAs are only available for TBAs previously trained by the Ghana Health service
***TBAs in Navrongo had stopped conducting deliveries

B. Recruitment strategy – Midwives only
1. Stratify by hospital, health centre and CHPS.
2. Also stratify by 2 sub-districts in each of three regions
3. Then select 2 from each cell except Navrongo B (no hospital)

Recruitment strategy- Midwives

	Hospital	Health centre	CHPS	Total
Dodowa A (Shai Osudoku)	2	2	2	
Dodowa B (Ningo-Prampram)	2	2	2	
Kintampo A (Kintampo North)	2	2	2	
Kintampo B (Kintampo South)	2	2	2	
Navrongo A (Kassena Nankana East- KNE)	2	2	2	
Navrongo B (Kassena Nankana West-KNW)	0	2	2	34

C. Recruitment strategy – TBAs only
1. Stratify by type of training-formal, informal and religious setting
2. Also stratify by 2 sub-districts each in the three regions
3. Then 2 from each cell except Navrongo (TBAs have stopped conducting deliveries)

Recruitment strategy – TBAs

	Formally trained	Informally trained	Religious setting	Total
Dodowa A (Shai Osudoku)	2	2	2	
Dodowa B (Ningo Prampram)	2	2	2	
Kintampo A (Kintampo North)	2	2	2	
Kintampo B (Kintampo South)	2	2	2	
Navrongo A (KNE)	0	0	0	
Navrongo B (KNW)	0	0	0	24

D. Total Numbers to recruit

	Doctors	Midwives	TBA	
Dodowa	3	12	12	
Kintampo	3	12	12	
Navrongo	3	10	0	
Total	9	34	24	67

6.2.3 Recruitment procedure and Data collection

During the field study, 71 maternity care providers were recruited from 55 service settings- 5 hospitals, 24 clinics and 26 home delivery services. This comprised all hospitals (2 in each surveillance area, except for Navrongo where there was only one hospital), 8 clinics (comprising 4 health centres and 4 CHPS facilities) from each surveillance area and 12 home settings from Kintampo and Dodowa. In Navrongo, TBAs had been banned from conducting deliveries for at least the past 3 years and in some communities, it is an offence punishable by a fine for a TBA to conduct deliveries. Therefore only 2 TBAs in the Navrongo HDSS were selected to share their current roles. Maternity care providers in hospitals included doctors and midwives, in clinics they were midwives and community health nurses, and in home delivery settings, they were TBAs. The numbers of doctors, midwives and TBAs finally recruited for the questionnaire survey by surveillance area are shown in Table 6.2

Table 6.2: Distribution of health care providers recruited for questionnaire survey

Health cadre	Surveillance area			Total (N=71)
	Kintampo (n=25)	Dodowa (n=28)	Navrongo (n=18)	
Doctor	4	2	3	9
Midwife in hospital	4	4	3	11
Midwife in health centre	4	5	4	13
Midwife in CHPS	1	5	6	12
TBA	12	12	2	26

The questionnaire survey and the subsequent in-depth interviews (Chapter 7), were carried out from October to December 2015, beginning with Kintampo and ending with Navrongo. The questionaires were administered via face-to-face interviews. A telephone directory of midwives and doctors within the study areas was generated with the help of the district public health nurse. Appointments with doctors and midwives selected for the study were booked via telephone, to avoid unnecessary travel and to provide healthcare staff with advance notice. For TBAs, an appointment was booked, where possible, through the community health nurse or surveys were conducted on the market day of the community because TBAs were more likely to be at home. The purpose of the research was first explained to healthcare workers via telephone and face-to-face meetings were only arranged upon verbal consent. The purpose of the research, components of the survey, possible risk and rights of the respondent were further explained during the face-to-face meetings and the survey was conducted after any questions were clarified and written consent, signature or thumbprint, was obtained. Specific ethical considerations in relation to the questionnaire survey are described at the end of this section.

6.2.4 Survey tool

To my knowledge, there was no suitable pre-existing questionnaire on the birth practices, management of adverse conditions, and opinions of maternity care providers related to neonatal mortality in Ghana. Consequently, a questionnaire (Appendix 3.3) comprising mainly closed questions and a few open-ended questions was designed to assess the neonatal birth and management practices in Ghana. This questionnaire was designed after a broad consultation with clinicians at the University of Glasgow and the Cape Coast Teaching Hospital, Ghana, and public health experts at Glasgow University and the collaborating institutions in Ghana to improve its validity and usefulness. The contents of the questionnaire were also informed by the risk factors and causes of neonatal mortality as found in previous studies. The questionnaire was piloted among 10 maternity care providers in the Abura-Asebu Kwamankese (AAK) district in the Central Region of Ghana to improve clarity and validity (Section 6.2.4). Responses from the pilot were fed back into the final design of the questionnaire before it was sent for ethics approval in each of the three health research centres.

The approved questionnaire was translated into the relevant local languages by experienced translators in the collaborating health research centres, to be used for the TBAs because most of them could not speak or understand English. The questionnaires for the midwives and doctors were in English. The TBA questionnaires were translated into Kassem and Nankan for the Kassena Nankana East district and Kassena Nankana West districts of the Navrongo HDSS areas respectively. For the Shai-Osudoku and Ningo Prampram districts of the Dodowa HDSS, the questionnaire was translated into Dangbe. The questionnaire for the Kintampo north and south districts in the Kintampo HDSS was translated into Twi. The purpose of the forward translation was conceptual rather than literal and for suitability to the intended audience. These are in line with the WHO's recommendations for translation and adaptation of instruments (http://www.who.int/substance_abuse/research_tools/translation/en/). The translated questionnaires were back-translated into English by four research assistants (section 6.2.5) - one each for the local languages in the HDSS. These research assistants also helped in the questionnaire administration. These research assistants were selected for the back-translation for two reasons; a) because they had the requisite language skills and b) to familiarise themselves with the questionnaire before the survey (forward translation was done by professional translators in the research centres before the field study).

The first page of the questionnaire was the information sheet - which introduced the researcher, collaborating institutions and the purpose of the research, potential benefits and risks to the participant, as detailed in the conditions for the ethics approval. Following that was the written consent form to be signed or thumb printed by participants and witnessed by the researcher and research assistant. The questionnaire covered the following sections;

a. Background characteristics: demographic and background characteristics of the maternity care provider.
b. Birth practices related to the adverse birth outcomes: birth asphyxia, prematurity and infections.
c. Healthcare related factors: questions regarding factors influencing access or barriers to the setting in which participant provided delivery services.
d. Post-delivery management practices: questions regarding the immediate management of babies following delivery. This included questions about breastfeeding practices and bathing habits.
e. Care provider’s skill score: participants rated their own skills regarding the management of birth asphyxia, infection and prematurity on a Likert scale from 1 (not good) to 5 (excellent).
f. Cultural factors: maternity care providers were requested to state cultural and belief patterns regarding how mothers or caregivers cared for babies within their communities.

6.2.5 Piloting and exploratory study

The questionnaire was piloted with five midwives and five TBAs in the Abura Asebu Kwamankese (AAK) district in the Central Region of Ghana. The aim of the pilot was to assess the comprehensibility and validity of the questionnaires and also identify further concepts which may be related to neonatal mortality but had not been included. The AAK district was selected based on the language proficiency of the researcher which allowed him to conduct interviews among the TBAs in Twi. The pilot study was carried out from 6th to 10th July 2015, at a rate of two interviews per day and each interview lasted approximately 60 minutes. Approval to carry out the pilot study in the district was given by the district health directorate.

Observations and lessons from the pilot study were fed back into the content and wording of the final questionnaire. A new construct which emerged during the exploratory study was hypothermia. Hypothermia is operationally defined as exposure of babies to cold temperatures (<35^{o}C). This had not been considered earlier because I had not identified any previous studies in Ghana or in the UK which had documented this. However, during the interviews with midwives in the hospital, it was revealed that exposing babies to cold conditions was associated with mortality. Consequently, hypothermia was included in the final questionnaire. A wider subsequent review of the literature confirmed that an association between exposure of babies to cold weather and mortality had been found in Ghana (310), Ethiopia (311) and Nepal (312, 313). Winter births were associated with higher risk of mortality compared to babies born in the spring months. Another systematic review showed that hypothermia contributed significantly to overall neonatal deaths in developing countries, although it was not considered a 'direct cause' of neonatal deaths (314). Brinkmann and Kvale (315), in their book *Interviews: Learning the Craft of Qualitative Research Interviewing*, emphasise that the purpose of exploratory studies is to discover new dimensions of the research topic. Questions which were not clear, particularly to the TBAs, because there was no vernacular for the medical terms were re-worded in the final questionnaire using familiar terminologies and phrases which maintained the meaning of the question.

6.2.6 Recruitment of Research Assistants

Overall four midwives with high proficiency in the relevant local languages, one each for Kassem, Nankan, Twi and Dangbe, were recruited to assist with questionnaire survey and interviews (Chapter 7). Midwives were preferred to other graduates with required language skill because they are familiar with the medical terminology contained in the interview guide, and thus could ask necessary follow-up questions to clarify TBAs responses. The language proficiency of these research assistants was assessed by requiring them to back translate the translated questions into English. This also helped assess the accuracy of the translations and any mistranslations or misunderstandings were clarified. The research assistants were educated on the aims of the research project, ethical issues and the interview process. Finally, mock interviews were conducted in English and the relevant local languages to evaluate the interview skills of the research assistants. It was also expected that the midwives would have acquired basic interviewing skills from their day jobs as they assessed and collected clinical information from their clients. The research assistants were allowed to interview TBAs after their interview skills were considered satisfactory and also after observing me interview at least two midwives and doctors in English.

6.2.7 Ethics considerations

This study and the tools used were approved by the institutional review boards and the ethics review committees of the three health research centres in Ghana (Appendices 1.1-1.3). In addition, written permissions were obtained from all the Regional and District Health Directorates covering the research surveillance areas before interviewing midwifes, doctors and TBAs (Appendices 1.4-1.7). In some communities, the significant community leader was informed on arrival in the community before TBAs were interviewed. This was culturally appropriate especially for smaller communities in which TBAs were regarded as a community resource. Written consent was also sought from maternity care providers after the purpose of the research and potential benefits and risks were explained. Participation in the survey was voluntary and respondents could withdraw at any point without any consequences to them. Appointments were rescheduled in cases where the meeting could not be conducted or completed due to unforeseen circumstances. All the healthcare workers preferred to be interviewed during working hours, thus surveys or interviews were seldom interrupted by obstetric emergencies. All data collected were kept completely anonymous. Aggregated results of the survey were reported to minimise the possibility of linking any response to a particular individual. These were all in accordance with the conditions of the ethics approval.

6.2.8 Statistical analyses

Maternity care providers were categorised into three groups, based on the delivery setting in which services were provided; hospital, clinics, and home. Descriptive statistics and bar graphs were used to summarise the survey data and chi-square statistics were used to show significant differences by place of delivery for categorical variables. Where the underlying assumptions for a chi-square test were not met, the Kruskal Wallis tests were used to test for statistical significance for categorical variables. A one-way ANOVA was used to check for differences in mean for continuous variables. The statistical significance was set at 0.05. All statistical analyses were carried out using Stata version 14 (StataCorp, Texas).

6.3 Results

Overall, 71 maternity care providers were included in the survey. Twenty-eight percent were doctors or midwives working in hospitals, 35% were midwives or community nurses in clinics (health centres or CHPS facilities), and 37% were TBAs who did home deliveries. Of the TBAs, 27% conducted deliveries in the patient's home only, 42% delivered women in the TBA's home only and 31% conducted deliveries in either the patient's or the TBA's home. When stratified by location, 28 (39%) maternity care providers practised in the Dodowa surveillance area, 25 (35%) were from the Kintampo surveillance area and 18 (25%) were from the Navrongo surveillance area. There was no statistical difference between the types of maternity care providers by region (p=0.06).

6.3.1 Background characteristics and types of maternity services

Table 6.3 summarises the background characteristics and types of maternity services according to the place of delivery. In terms of the overall number of years of maternity care provision experience, TBAs had significantly longer years of practice experience with an average of over 20 years but the fewest deliveries per month; doctors or midwives in hospitals and clinics had fewer years of practice experience but more deliveries per month. The commonest adverse birth outcome experienced by maternity care providers was birth asphyxia, which had been experienced by 83% (n=59) of care providers and the rarest adverse neonatal outcome was death which had been experienced by 42%

(*n*=30). There was a statistically significant difference in adverse neonatal experiences by type of maternity care provider. Doctors and midwives in hospitals were more likely to have experienced all the adverse neonatal outcomes under investigation (Premature rupture of membranes (PROM), birth asphyxia, preterm delivery and neonatal death). Midwives in clinics were less likely than hospital staff and TBAs to have experienced PROM and birth asphyxia and TBAs in homes were less likely than midwives and doctors to have experienced preterm births, neonatal infection and deaths. In terms of birth practice, only one hospital staff member and one TBA indicated that they had given a warm water enema for newborns to remove hard stools or make the baby pass meconium. Sixty-eight percent of midwives in clinics said they had not given an enema because ‘it was not part of the management protocol’, and more than a quarter of TBAs said it was ‘bad practice’ (*n*=7).

Also, the table shows that it took about 30 minutes on average to drive from home delivery settings to the nearest clinic or hospital, 45 minutes to drive from clinics to the nearest hospital and an hour by car from a hospital to the next hospital. The difference in drive time from one type of delivery facility to the nearest point of referral was statistically significant (p=0.01). Although 80% of maternity care providers in hospital and 40% of those in clinics said women and babies were transferred using an ambulance, the survey does not show the proportion or characteristics of patients transferred by ambulance. At least 50% of maternity care providers in all the delivery settings said it was the patient’s responsibility to arrange transportation when transferred, though there were a few times when care providers used their personal cars or motor bikes to transport patients to the nearest hospital. The majority of care providers (76% hospital, 70% clinic, 76% home) said it took less than 30 minutes to access a vehicle to transport women or babies from their delivery facility to the nearest referral point at odd hours but nearly 20% of clinic staff said it could take up to 3 hours to get a vehicle at odd hours. Odd hours were defined as any day in a week and hour of the day which was considered the most difficult to access a vehicle. It differed from community to community and ranged from non-market days to nights.

Figure 6.1: Source of traditional birth attendant training

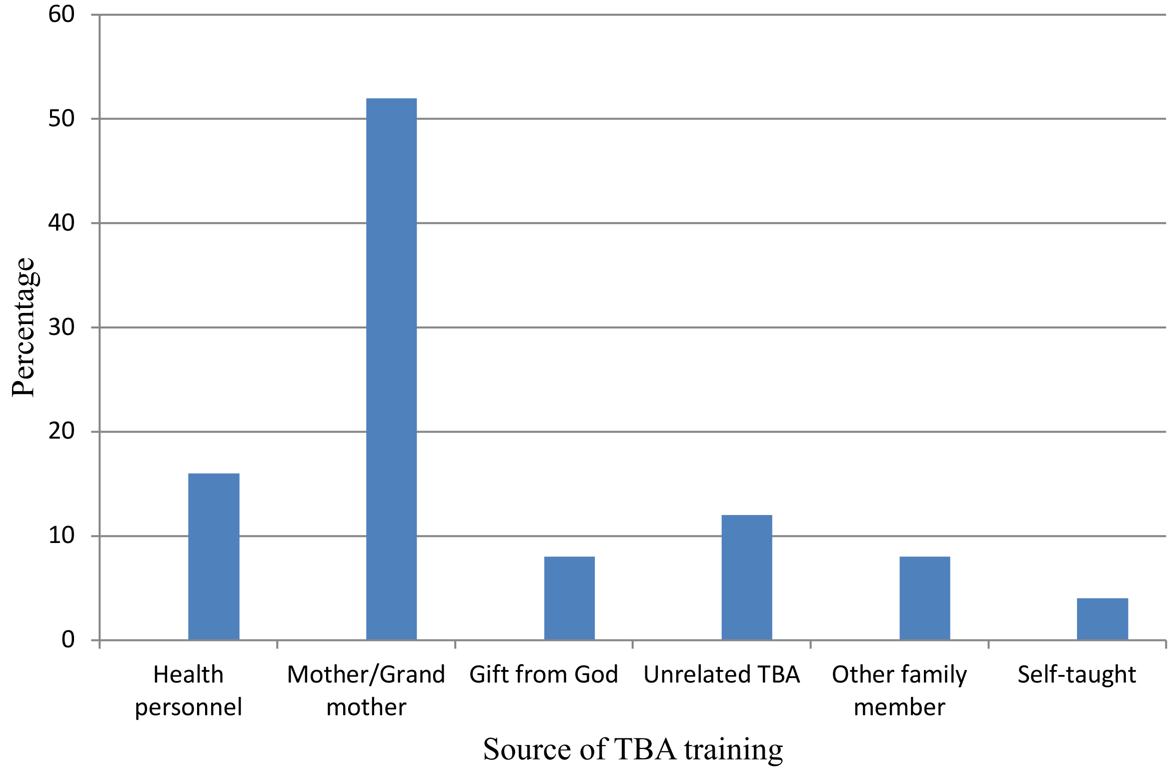


Figure 6.1 shows the primary source from which TBAs received training to provide maternity services. It is clear that the majority of TBAs (60%) were trained by a family member, mostly their mother or grandmother (52%). Irrespective of the primary source of training, all but one TBA said they had received some additional form of TBA refresher or top-up training organised by the Ghana Health Service (GHS).

Table 6.3: Background characteristics

	Hospital (N=20)	Clinic (N=25)	Home (N=26)	p-value*
Surveillance area (n (%))				
Navrongo	6 (30)	10 (40)	2 (8)	0.64
Kintampo	8 (40)	5 (20)	12 (46)	
Dodowa	6 (30)	10 (40)	12 (46)	
Walking time to nearest referral point (n (%))				
<30 minutes	0	0	7 (28)	0.001
30 mins- 1 hour	0	3 (12)	6 (24)	
1-2 hours	1 (6)	0	2 (8)	
Not walkable	17 (94)	22 (88)	10 (40)	
Driving time to the nearest referral point (minutes) *X* (range)	65 (30-120)	48 (5-180)	31 (2-90)	0.01
Mode of transport between facilities (n (%))				
Taxi driver on call	1 (5)	10 (40)	9 (35)	0.03
Ambulance[1]	16 (80)	10 (40)	1 (4)	<0.001
Patient responsibility	12 (60)	16 (64)	13 (50)	0.53
Walk distance	1 (5)	1 (4)	5 (19)	0.14
Ease of getting car at odd hours (n (%))				
<30 minutes	13 (76)	16 (70)	16 (76)	0.78
30 minutes- 1 hour	4 (24)	3 (13)	5 (24)	
1-3 hours	0 (0)	4 (17)	0 (0)	
Cost to nearest facility GHC (Mean (range))				
Minimum cost	80 (6- 300)	22 (0- 60)	30 (0-300)	0.001
Maximum cost	97 (40-200)	57 (10- 100)	52 (8- 200)	0.2
Experience years Mean (min- max)	5.1 (0.25-29)	5.8 (0.25-24)	21.7 (4-50)	<0.001
Regional experience Mean (min- max)	3.0 (0.25-14)	2.8 (0.08-10)	17.9 (1-40)	<0.001
Previous experience (n (%))				
PROM	20 (100)	15 (60)	19 (73)	0.01
Preterm delivery	19 (95)	14 (56)	9 (35)	<0.001
Birth asphyxia	20 (100)	18 (72)	21 (81)	0.04
Neonatal infection	19 (95)	16 (64)	13 (50)	0.01
Neonatal death	13 (65)	9 (36)	8 (31)	0.05
Number of deliveries per month (Mean (min- max))	46 (0-80)	13 (3-40)	13 (4-28)	<0.001
PROM: Premature rupture of membranes				
1: Ambulance is defined as any transport means-van, car or tricycle-designated for the purpose of transporting patients in emergencies.				
*One way ANOVA for Driving time to nearest referral point, Cost to nearest facility, Experience and Regional Experience				
*Unless specified, all analyses were chi square tests, and Kruskal-Wallis test was used where assumptions for chi square were not met				

6.3.2 Type of maternal services provided

Except for spontaneous vaginal delivery (SVD) and taking care of sick babies, Table 6.4 shows significant differences in the type of services provided by type of maternity care provider. Only maternity care providers based in hospitals offered caesarean section, out of which two said they provided planned caesarean section only because they did not have a resident anaesthetist. In addition to conducting SVDs, 65% of TBAs said they cared for sick pregnant women and 35% said they cared for sick babies. TBAs were more likely to say they provided spiritual support for women in labour (77%), visit mothers following delivery (62%) and manage women in labour with herbal concoctions (38%). Less than 40% of hospital staff and TBAs said they permitted family members to be present when conducting delivery. The majority of maternity care providers indicated that the first place women were likely to seek treatment for neonatal illness was the clinic or hospital. However, according to the TBAs, mothers sought herbal treatment from TBAs or other traditional healers if they perceived the neonatal illness to be ‘asram’ disease.

Table 6.4: Type of maternal services provided

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Type of services provided				
Spontaneous vaginal delivery	20 (100)	24 (96)	25 (96)	0.67
Assisted vaginal delivery	14 (70)	1 (4)	0 (0)	<0.001
Caesarean section	14 (70)	0 (0)	0 (0)	<0.001
Care of pregnant women	20 (100)	24 (96)	17 (65)	<0.001
Care of sick babies	18 (90)	24 (96)	9 (35)	<0.001
Services provided				
Spiritual support	3 (15)	3 (12)	20 (77)	<0.001
Herbal concoction	0	0	10 (38)	<0.001
Permit family presence	7 (35)	16 (64)	6 (23)	0.02
Offer prenatal services	11 (55)	18 (72)	10 (38)	0.1
Mothers deliver in any position	1 (5)	13 (52)	6 (23)	0.002
Check-up via telephone (postnatally)	0	8 (32)	4 (15)	0.02
Service is free	6 (30)	13 (52)	4 (15)	0.04
Home visits	2 (10)	14 (56)	16 (62)	<0.001
We help mothers take care of babies	2 (10)	8 (32)	10 (38)	0.05
First care seeking place if baby is sick				
Clinic	11 (55)	19 (76)	15 (58)	0.3
Hospital	9 (45)	3 (13)	6 (23)	
TBA	0	1 (4)	4 (15)	
Home	0	0	1 (4)	
Soothsayer	0	1 (4)	0	
*Chi square test was used for all categorical variables and where assumptions were not met, Kruskal Wallis test for significance was used.				

Figure 6.2: Obstetric characteristics of deliveries conducted by health care workers

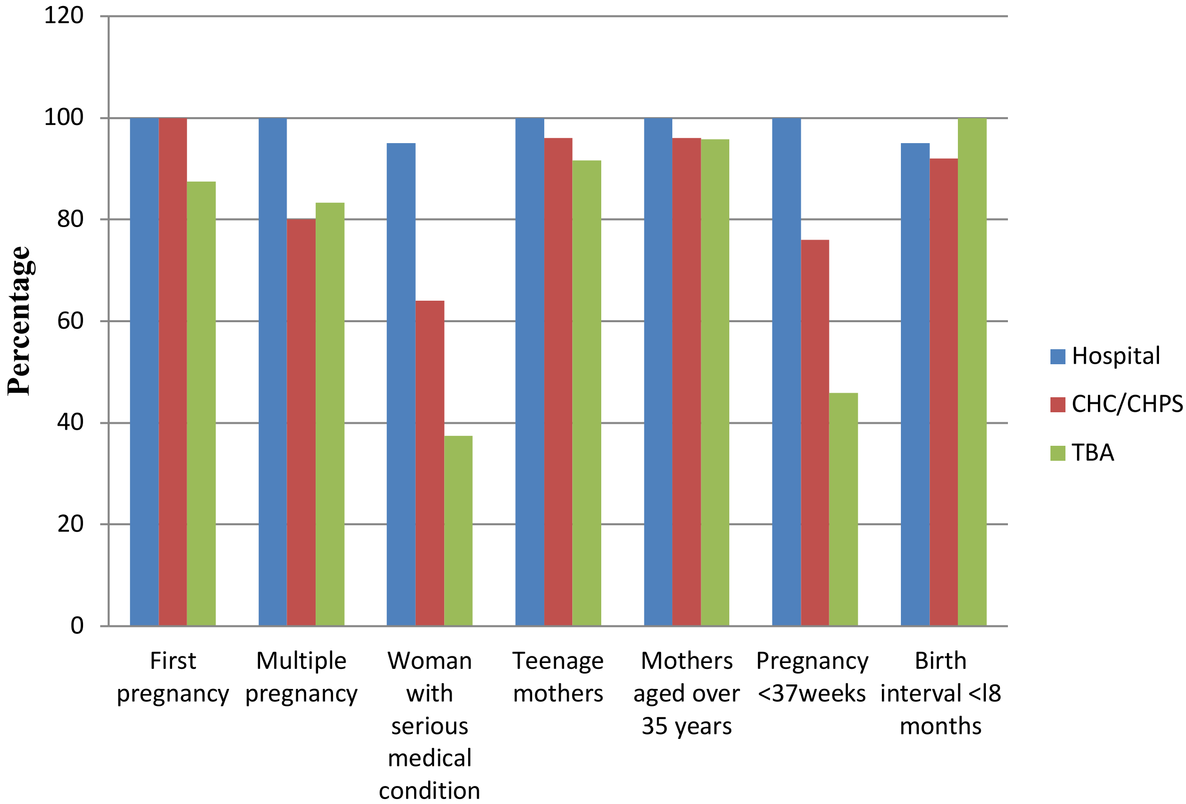


Figure 6.2 shows the obstetric characteristics of deliveries conducted by place of delivery. The bar graph shows hospitals indicated they delivered all women, regardless of obstetric risk. Significant differences appeared to exist in the management of women with serious medical conditions or premature births. Less than 80% of midwives in clinics and less than 50% of TBAs indicated they managed pregnancies which were less than 37 weeks gestation or women with serious medical conditions, like pre-eclampsia.

6.3.3 Healthcare providers' opinions of factors influencing or barriers to maternity care

This section presents the results of factors maternity care providers perceived to influence women's preference to use their facilities and opinions about factors which prevented women from seeking delivery services from their facility.

Figure 6.3: Care providers views on factors influencing maternal preference for place of delivery

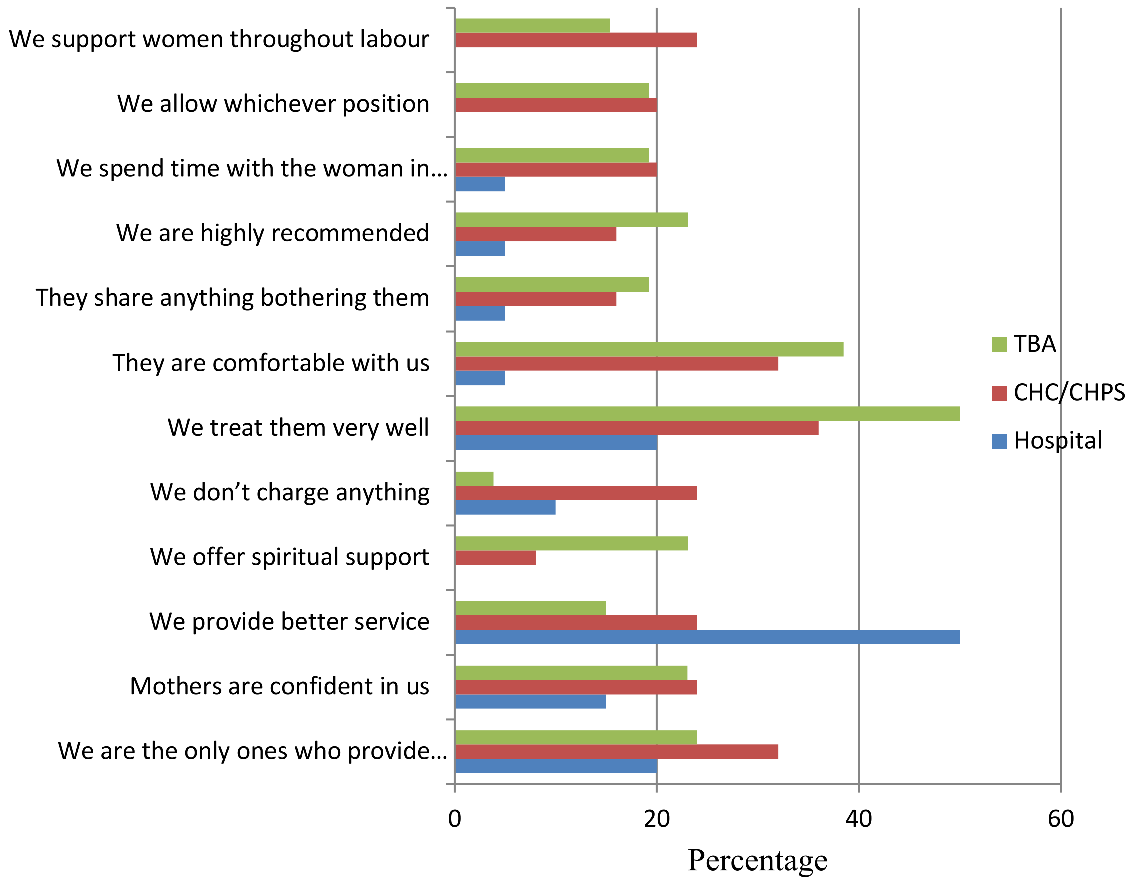


Figure 6.3 shows the factors which maternity care providers believed to influence women's choice of place for maternity services. The most striking observations were that TBAs believed that women chose their services because they treated them well, and staff in hospital said women were attracted to their services because they offered a 'professional service' and could manage complications. Close to 50% of TBAs said they 'pampered' women who came to their facilities 'unlike the hospitals' where some women were 'beaten or shouted at'. Some TBAs (20%) said women believed in the concoctions they used and thus preferred to be delivered at home. Thirty-six percent of midwives in clinic said they gave free beverages for breakfast, methylated spirit or diapers to women who came to be delivered.

Figure 6.4: Health care workers' perceptions of barriers to seeking care

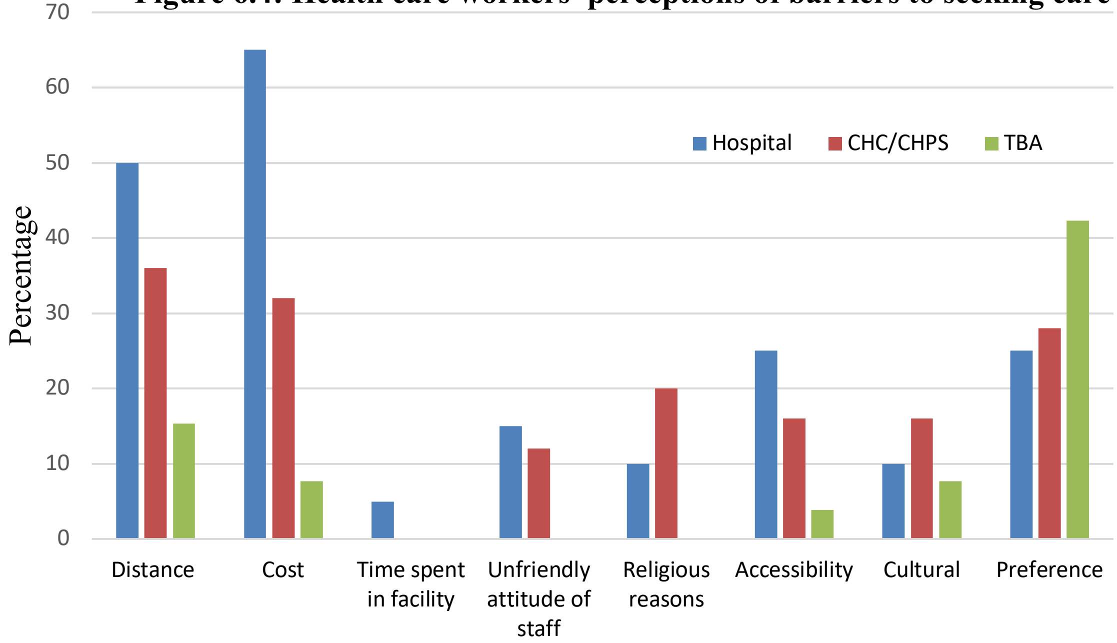


Figure 6.4 shows the factors HCWs believed were barriers to mothers seeking maternity services from their facilities. According to doctors and midwives in hospitals and clinics, the major barriers to care were: high cost of services (65% and 32% respectively), and long or un-drivable distances (50% and 36% respectively). TBAs believed that women may not attend their facilities because they preferred other settings (42%). It was surprising that when asked for the cost of delivery services no hospital staff and only one clinic midwife said they charged a fee for delivery. Anecdotal information indicated, however, that women seeking delivery services in hospitals paid undocumented and indirect costs of up to GHC 100 for registration, ward dues, or other items used for deliveries, and costs could be higher if delivery was complicated and women requested blood transfusion or surgical intervention. Women also paid for drugs used for delivery that were not covered by the national health insurance scheme (NHIS). TBAs said they charged up to GHC 100 for delivery services, with an option to pay in instalments, and some TBAs charged higher for delivery of boys or double for twins. Mothers who were delivered also showed appreciation by giving gifts in the form of yam, okra, or other food stuff to maternity care workers, especially to TBAs.

6.3.4 Pregnancy list requested by health care providers

Table 6.5 is a summary of items requested from women who sought delivery services in various delivery settings in Ghana. All women being delivered were required to bring some combinations of the listed items below, even in settings which said there was no monetary charge for delivery services. There was a large overlap in the list of major items requested in all the settings: soaps, bleach, antiseptic solution, toilet rolls and water-proof sheet. Maternity care providers often retained the consumable products and those that could be reused were returned to mothers. The quantities of these items requested from mothers differed between delivery settings. For example, the number of soaps requested by midwives in hospitals and clinics ranged between 2 to 4 large bars of Unilever Geisha® soap and TBAs were often unspecific about the type or number of soaps.

Table 6.5: Pregnancy list requested by health providers

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)
Baby items			
Cot sheet	5 (25)	6 (24)	3 (12)
Baby clothes	4 (20)	4 (16)	1 (4)
Baby diapers	1 (5)	1 (4)	1 (4)
Baby oil	1 (5)	1 (4)	1 (4)
Delivery items			
Water proof sheet	5 (25)	9 (36)	5 (19)
Sanitary pad	7 (35)	11 (44)	4 (15)
Soap	5 (25)	8 (32)	11 (42)
Bleach (Parazone)	4 (20)	5 (20)	10 (39)
Delivery mat	5 (25)	5 (20)	2 (8)
Antiseptic solution (Detol®/ Savlon®)	7 (35)	10 (40)	11 (42)
Bucket	1 (5)	1 (4)	0
Toilet roll	3 (15)	0	7 (30)
Hair net	1 (5)	0	0
Alcohol	0	0	1 (4)
Battery	0	0	1 (4)
Methylated spirit	2 (10)	0	0
Chamber pot	0	0	1 (4)
Eggs (crate)	0	0	2 (8)
Cost of SVD delivery			
<GHC 50	0	1 (4)	4 (15)
GH 50-100	0	0	9 (35)
>GHC 100	0	0	2 (8)

6.3.5 Birth practices related to neonatal infection

Table 6.6 is an inventory of items used by maternity care providers in delivering women. The table shows significant differences in the items used in delivery between the delivery settings. The majority (>50%) of hospitals in the survey had most (20/22) of the listed items for delivery or management of neonatal complications. The majority of the clinics had at least 54% of the listed delivery items and more than half of TBAs in the homes had only five out of the 22 listed items. The majority (>50%) of births conducted by TBAs were therefore done with very rudimentary equipment and less than 10% of the TBAs had breathing apparatus or a suction pump and none had oxygen or an incubator to manage neonatal complications. TBAs who indicated they had 'breathing apparatus' described it as an improvised device made of the neck of a plastic bottle through which they pumped air into the nostrils of the newborn.

Table 6.6: List of Instruments used in the management of delivery

Instrument	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Gloves	20 (100)	25 (100)	23 (88)	0.4
Fetoscope	20 (100)	25 (100)	3 (12)	<0.001
Bulb syringe	20 (100)	25 (100)	9 (35)	<0.001
Cord clamps/cords	18 (90)	25 (100)	19 (73)	0.05
Weighing scale	19 (95)	24 (96)	2 (8)	<0.001
Breathing apparatus	19 (95)	24 (96)	2 (8)	<0.001
Swab	19 (95)	24 (96)	21 (81)	0.47
Cleaning solution	19 (95)	25 (100)	21 (81)	0.17
Scissors	19 (95)	25 (100)	3 (12)	<0.001
Artery forceps	18 (90)	24 (96)	3 (12)	<0.001
Vital tray	19 (95)	25 (100)	5 (19)	<0.001
Delivery bed	19 (95)	25 (100)	8 (31)	<0.001
Suction pump	16 (80)	9 (36)	1 (4)	<0.001
Blade	14 (70)	8 (32)	23 (88)	<0.001
Ventouse for vacuum	17 (85)	1 (4)	0	<0.001
Oxygen	17 (85)	5 (20)	0	<0.001
Ambulance (or access to)	15 (75)	11 (44)	0	<0.001
Pulximeter	10 (50)	1 (4)	0	<0.001
Forceps for delivery	3 (15)	3 (12)	0	0.16
Glucometer	13 (65)	0	0	<0.001
Incubator/ radiant warmer	10 (50)	0	0	<0.001
Doppler/USG scanner	4 (20)	0	0	<0.001

Figure 6.5: Infection prevention practices among health care workers

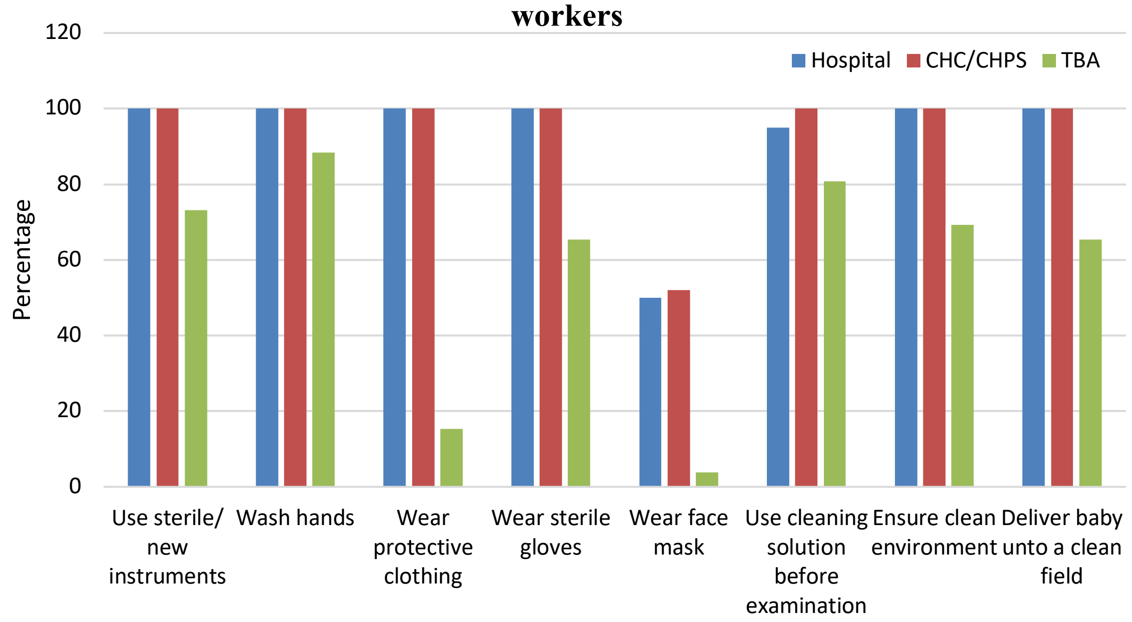


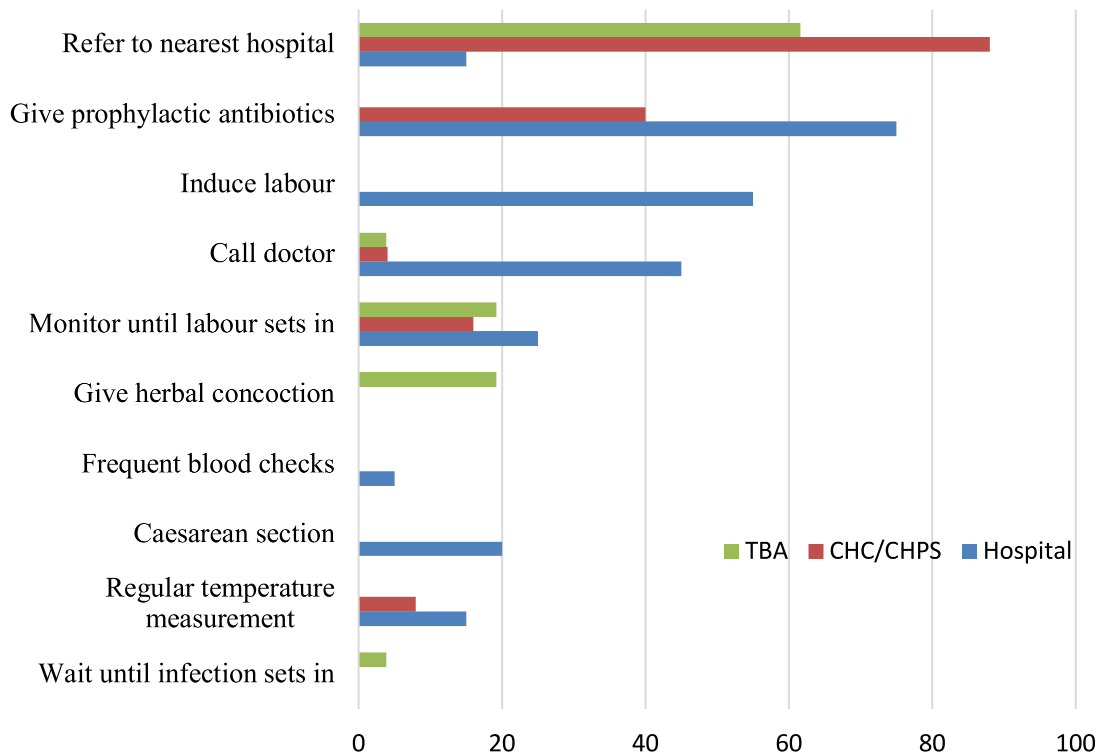
Figure 6.5 shows maternity care providers' adherence to infection prevention practices. It is clear from the bar graph that, except for wearing a facemask, staff in hospitals and clinics had consistent high infection prevention standards, but fewer TBAs adhered to the listed infection prevention measures. When asked which solutions they used to disinfect their delivery sites, all the care providers in hospitals and clinics and 64% of TBAs indicated they used chlorine-based solution. The remainder of the TBAs used any other disinfectant or soap and water only.

6.3.6 Management of mother relevant to neonatal infection

Table 6.7 describes various management practices of the mother relevant to neonatal infection. There was no significant difference in the assessment of mothers in labour by delivery setting, except for assessing fetal heart rate, but there were significant differences in the management of maternal conditions relevant to neonatal infection. Most (88%) of the TBAs did not have fetoscopes to assess fetal heart rate (Table 6.6), thus the few who assessed fetal heart rate either rested their ear against the woman's abdomen or felt it with their fingers. Regarding the procedure for conducting vaginal examination, all hospital and clinic staff and more than 80% of TBAs said they washed their hands, wore gloves and swabbed the vulva of women in labour. Sixty-five percent of TBAs said they used cleaning solution before vaginal examination (compared to 100% of midwives and doctors in hospital and clinic) and none of hospital staff or TBA used a lubricating gel prior to vaginal examination.

Over 80% of midwives in clinics and TBAs in the homes said they would refer any woman whose membranes ruptured before labour sets in less than 37 weeks of gestation (PPROM) to the hospital and 80% of hospital staff said they would manage such women with prophylactic antibiotics and encourage bed rest. When asked to describe the management of a woman with vaginal or urethral tract infection at the time of labour, more than 50% of hospital and clinic staff agreed that, among other things, they would consider administering intrapartum antibiotics or treating infection after delivery. No TBA said they would give antibiotics before or after delivery but only 38% said they would refer women who had active infections in labour, and 12% said they would treat with herbal concoctions. The rest of the TBAs said they would simply clean any urethral fluid with or without antiseptic and then continue to deliver the woman. Surprisingly, none of the maternity care providers said they would take a high vaginal swab for laboratory investigations.

Figure 6.6: Management of preterm rupture of membranes



The protocol for managing PROM by setting of delivery is shown in Figure 6.6. It was common for midwives in clinics and TBAs to refer cases of PROM to the nearest hospital and the commonest management procedure among hospital staff was to administer prophylactic antibiotics. It is important to mention that doctors and midwives in hospitals indicated that each clinical case was treated on its own merits. These management procedures described were therefore applicable in a general and uncomplicated case.

Table 6.7: Management of mother relevant to neonatal infection

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Assessment of mother during labour				
Observation	20 (100)	25 (100)	23 (88)	0.39
Palpation	20 (100)	25 (100)	22 (85)	0.15
Vaginal examination	20 (100)	25 (100)	21 (81)	0.05
Fetal heart rate	20 (100)	25 (100)	9 (35)	<0.001
Management of PPROM**				
Give prophylactic antibiotics	16 (80)	7 (28)	0	<0.001
Administer steroids	11 (55)	0	0	<0.001
Induce labour	7 (35)	0	1 (4)	0.001
Caesarean section	7 (35)	0	0	<0.001
Monitor fetal wellbeing	6 (30)	2 (8)	1 (4)	0.02
Wait until gestation is 36 weeks	2 (10)	0	0	0.08
Wait until labour sets in	2 (10)	1 (4)	2 (8)	0.72
Wait until you see signs of infection	1 (5)	1 (4)	2 (8)	0.68
Regular measurement of temperature	2 (10)	2 (8)	0	0.30
Laboratory investigations	1 (5)	0	0	0.28
Call doctor	9 (45)	0	1 (4)	0.001
Refer to nearest hospital	3 (15)	22 (88)	21 (81)	<0.001
Give herbal concoction	0	0	6 (23)	0.003
Management of mother with an infection in labour				
Give intrapartum antibiotics	18 (90)	17 (68)	0	<0.001
Treat infection after delivery	17 (85)	13 (52)	0	<0.001
Expedite delivery with oxytocin	11 (55)	6 (24)	0	<0.001
Do caesarean section	3 (15)	0	0	0.02
Continuous monitory of baby in utero	8 (40)	7 (28)	0	0.003
Call doctor	5 (25)	2 (8)	0	0.01
Give herbal medication	0	0	3 (12)	0.07
Refer to nearest hospital	1 (5)	13 (52)	10 (38)	0.003
**PPROM: Preterm premature rupture of membranes				
*Unless specified, all analyses were chi square tests, and Kruskal-Wallis test was used where assumptions for chi square were not met				

6.3.7 Management of baby relevant to neonatal infection

Table 6.8 shows the management of neonatal conditions relevant to infection. There was no significant difference in overall neonatal assessments and cord dressing by delivery setting, but there were significant differences in the management of other neonatal conditions. All hospital staff, 96% of clinic staff and 58% of TBAs indicated that they dressed the cord stump of the newborn with methylated spirit only. TBAs who did not use methylated spirit used either shea butter (15%), alcohol (8%), boiled cooled water (8%), sand (4%), white chalk (4%) or Pepsodent® toothpaste (4%). It was interesting to notice that while clinic staff who did not use methylated spirit indicated they did not apply anything to the cord stump, the TBAs always applied something.

The majority of midwives in clinics (68%) and TBAs in homes (62%) said they would refer babies born to women with active infection in labour to the nearest hospital. The rest of the midwives said they would assess the vital signs of the baby and TBAs said they would simply wipe any odours off the baby. Approximately 20% of TBAs said they would manage a sick baby (for example with high temperature and irritable) with herbal medications and almost all midwives in clinics said they referred babies born sick to the nearest hospital, and nearly 50% said they also administered medications. In hospitals, babies born to mothers with infection during labour and sick babies were assessed and given appropriate medications.

Table 6.8: Management of baby relevant to neonatal infection

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Assessments of baby after delivery				
Suckling	20 (100)	25 (100)	23 (88)	0.39
Crying	20 (100)	25 (100)	23 (88)	0.39
Movement	20 (100)	25 (100)	23 (88)	0.39
Breathing	20 (100)	25 (100)	23 (88)	0.39
Colour	20 (100)	25 (100)	18 (69)	0.02
Pulse	19 (95)	23 (92)	11 (42)	<0.001
Grimace	20 (100)	25 (100)	8 (31)	<0.001
Cord dressing solution				
Methylated spirit	20 (100)	24 (96)	15 (58)	0.18
Shea butter cream	0	0	4 (15)	
Nothing	0	1 (4)	0	
Other	0	0	7 (27)	
Management of a baby whose mother had infection in labour				
Observe baby	8 (40)	10 (40)	0	0.001
Give antibiotics	16 (80)	9 (36)	0	<0.001
Give herbal concoction	0	0	1 (4)	0.28
Refer baby to nearest referral facility	1 (5)	17 (68)	16 (62)	<0.001
Inform doctor	6 (30)	1 (4)	1 (4)	0.006
Management of a baby born sick				
Assess baby	14 (70)	20 (80)	2 (8)	<0.001
Administer orthodox medication	13 (65)	12 (48)	2 (8)	<0.001
Administer concoction	0	0	5 (19)	0.01
Refer to nearest referral facility	5 (25)	24 (96)	23 (89)	<0.001
Refer to traditional healer	0	1 (4)	0	0.39

6.3.8 Preterm birth management practices

Table 6.9 shows the preterm birth management practices among health care providers, by delivery setting. Almost all HCW in hospitals or clinics and more than half the TBAs said they weighed babies immediately after delivery. Since only 8% of TBAs had weighing machines (Table 6.6), most of them guessed the birth weight by lifting the baby up after delivery or they sent the baby to the nearest facility within the first week. Almost all TBAs believed that a baby was viable to be delivered at 7 months (approximately 28 weeks) gestation but they believed a baby delivered at 8 months could not survive. In defence, the TBAs explained that at seven months, the fetus would have developed to a 'human', but it 'melted back into blood at 8 months' and then finally reforms into a complete human in the ninth month.

There were statistically significant differences in the assessment and management of preterm babies by delivery setting. While over 90% of HCWs in hospitals and clinics assessed gestational age using early booking scans, if the woman had one, the majority (65%) of TBAs relied on maternal recall of last menstrual period to assess gestation. Almost all midwives in clinics and TBAs said they referred preterm babies to the hospital and half of hospital staff said they managed preterm babies in the neonatal intensive care unit (NICU) or advised mothers to maintain adequate warmth and nutrition for the baby. The structure and facilities available in NICUs differed between hospitals but the hospitals considered they had a NICU if they had at least an incubator and an oxygen cylinder. None of the hospitals included in this survey had a qualified paediatrician.

Table 6.9: Preterm birth management practices

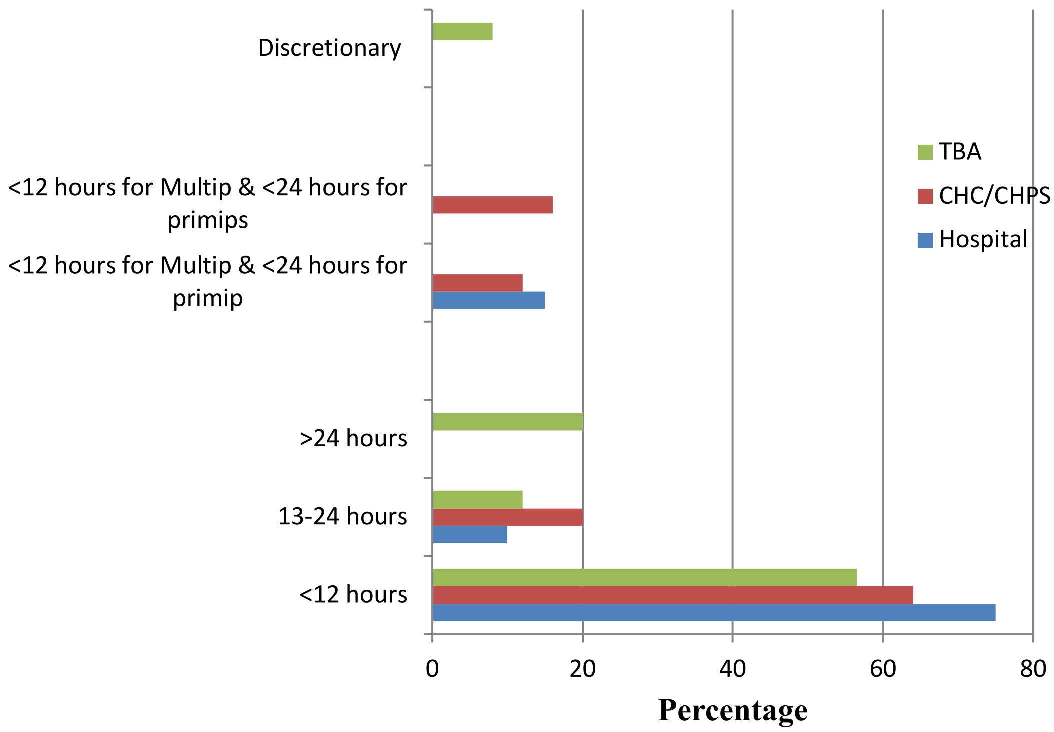
	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
When do you check weight after birth				
Immediately	20 (100)	24 (96)	12 (57)	<0.001
Never	0	1 (4)	9 (43)	
Definition of normal weight				
2.5- 4 Kg	17 (85)	25 (100)	4 (15)	<0.001
>2 Kg	3 (15)	0	0	
Not applicable	0	0	22 (85)	
Definition of preterm				
<28 weeks gestation	0	0	1 (4)	0.14
28-<37 weeks gestation	17 (89)	20 (80)	23 (96)	
32-<37 weeks gestation*	2 (11)	5 (20)	0	
>=37 weeks gestation	0	0	0	
Assessment of preterm before delivery				
Ask mother for gestation	8 (40)	12 (48)	17 (65)	0.10
Assess early booking scan	19 (95)	23 (92)	3 (12)	<0.001
Assess last menstrual period	6 (30)	8 (32)	3 (12)	0.23
Palpate for uterine size	9 (45)	18 (72)	16 (62)	0.15
Check fundal height	15 (75)	17 (68)	3 (12)	<0.001
Assessments on a preterm baby				
Assess suckling reflex	19 (95)	25 (100)	19 (73)	0.03
Assess swallowing reflex	18 (90)	25 (100)	11 (42)	<0.001
Check birth weight	20 (100)	24 (96)	9 (35)	<0.001
Check breathing pattern	20 (100)	25 (100)	18 (69)	0.002
Observe baby	19 (95)	24 (96)	18 (69)	0.04
Management of LBW				
Refer to NICU	10 (50)	2 (8)	0	<0.001
Check blood sugar	6 (30)	0	0	<0.001
Call doctor	3 (15)	1 (4)	1 (4)	0.24
Refer to nearest referral facility	2 (10)	18 (72)	19 (73)	<0.001
Refer to traditional healer	0	0	1 (4)	0.40
Advise mother- warmth, hygiene and feeding	15 (75)	22 (88)	5 (19)	<0.001
Refer to specialist	1 (5)	1 (4)	0	0.55
Management of a preterm baby				
Refer to NICU	10 (50)	1 (4)	0	<0.001
Call doctor	3 (15)	2 (8)	0	0.16
Refer to nearest referral facility	7 (35)	23 (92)	23 (89)	<0.001
Refer to specialist	1 (5)	0	0	0.29
Advise mother- warmth and feeding	10 (50)	10 (40)	2 (8)	0.007
Almost all care providers knew that preterm is less than 37 weeks but some defined the range to be from 32-<37 and no one said preterm included more than 37 weeks of gestation				

6.3.9 Birth asphyxia management practices

Table 6.10 shows significant differences in birth and management practices of asphyxiated babies in Ghana, by delivery setting. All staff in hospitals and clinics assessed progress of labour by timing contractions, vaginal examination, and monitoring fetal heart rate. Among TBAs, 77% monitored labour progress via vaginal examination but only 35% monitored fetal heart rate and less than 5% timed the contractions of a woman in labour. Almost all staff in hospitals and clinics said they used a partograph to monitor labour progress but more than 75% of TBAs did not take any records. When asked the maximum time HCWs allowed a woman to be fully dilated before taking further action, staff in clinics and hospitals said they allowed between 15-60 minutes for first time mothers and TBAs said they allowed between 30 minutes and 24 hours, but all HCWs agreed they would not allow multiparous women to be fully dilated for more than 2 hours before taking further action. When asked which actions maternity care providers would take following the maximum wait period for full dilatation without delivery, more than half of TBAs and midwives in clinics said they would refer a woman to nearest hospital.

Regarding management of a baby with meconium stained amniotic fluid, more than half of hospital staff and 40% of clinic staff said they would administer antibiotics, in addition to suctioning and resuscitating and 42% of TBAs said they would refer the baby. 50% of the TBAs also said they would simply wipe meconium off the baby. Eight percent each of midwives in clinics and hospitals said they administered vitamin K injection and 12% of clinic midwives said they would administer intravenous infusion of saline or dextrose to babies who were born with meconium stained amniotic fluid.

Figure 6.7: Maximum duration of labour permitted by health care

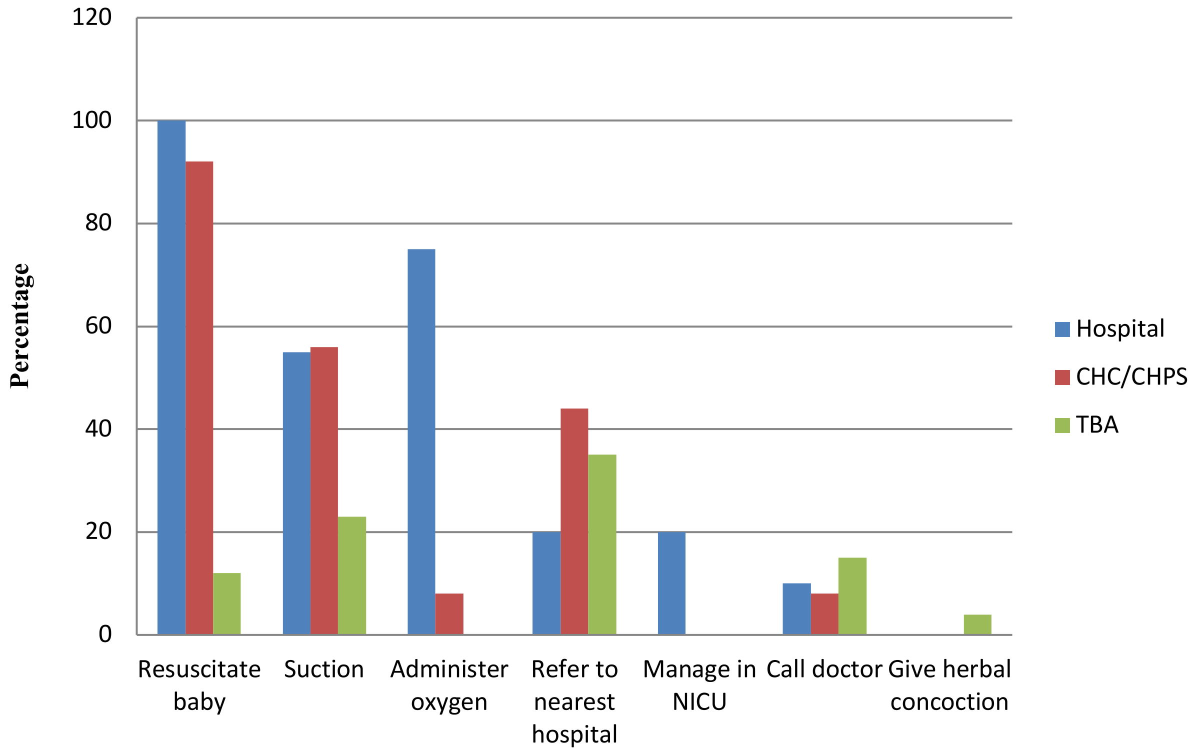


The bar graph in Figure 6.7 above shows the maximum time maternity care providers in Ghana said they allowed a woman to be in labour before taking further action. More than 50% of all health care providers said they took further action if pregnant women laboured for up to 12 hours without expected progress (after 3 consecutive vaginal examinations 4 hours apart), and 20% of TBAs only said they could allow women to labour for more than 24 hours.

Table 6.10: Birth asphyxia management practices

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Assessments for an asphyxiated baby				
Measure heart rate	19 (95)	24 (96)	6 (23)	<0.001
Measure pulse	17 (85)	21 (84)	4 (15)	<0.001
Measure temperature	14 (70)	14 (56)	1 (4)	<0.001
Measure blood pressure	1 (5)	3 (12)	0	0.20
Measure oxygen level	6 (30)	1 (4)	0	0.002
Assess blood glucose level	6 (30)	0	0	<0.001
Assess urinary output	4 (20)	5 (20)	3 (12)	0.74
Observe baby	0	2 (8)	10 (39)	<0.001
Documentation of labour progress				
Use partograph	20 (100)	23 (92)	0	<0.001
Use patient case notes	0	2 (8)	1 (4)	
Simple observation	0	0	5 (19)	
No records	0	0	20 (77)	
Maximum time to be in full dilation				
Primiparous (minutes)	42.6 (15-60)	40 (15-60)	140.5 (30-1440)	0.12*
Multiparous (minutes)	36. 9 (25-60)	49.2 (20-120)	90 (60-120)	0.04*
Actions after maximum time in full dilation				
Caesarean section	7 (35)	0	0	<0.001
Give prophylactic antibiotics	0	1 (4)	0	0.41
Regular measurement of temperature	1 (5)	3 (12)	0	0.21
Give herbal concoction	0	0	2 (8)	0.16
Call doctor	7 (35)	0	0	<0.001
Refer to nearest hospital	6 (30)	23 (92)	18 (69)	<0.001
Actions after maximum waiting period (overall)				
Listen to fetal heart rate	4 (20)	5 (20)	0	0.06
Give oxytocin	10 (50)	1 (4)	0	<0.001
Caesarean section	7 (35)	0	0	<0.001
Call doctor	9 (45)	1 (4)	0	<0.001
Give herbal concoction	0	0	6 (23)	0.003
Refer to nearest hospital	5 (25)	23 (92)	17 (65)	<0.001
Management of a baby with meconium stained amniotic fluid				
Suction once the head is out	9 (45)	14 (56)	1 (3.85)	<0.001
Suction after full delivery	15 (75)	13 (52)	2 (7.69)	<0.001
Resuscitate baby	13 (65)	15 (60)	1 (4)	<0.001
Administer antibiotics	12 (60)	5 (20)	0	<0.001
Call doctor	3 (15)	0	0	0.02
Monitor baby	2 (10)	7 (28)	0	0.01
Refer baby	3 (15)	10 (40)	11 (42)	0.10

Figure 6.8: Management of birth asphyxia



The bar graph in Figure 6.8 depicts the management of neonatal asphyxia by place of delivery. All hospital staff and more than 90% of midwives in clinics said they resuscitated an asphyxiated newborn with an ambu-bag but less than 15% of TBAs said they would resuscitate. None of the TBAs said they would administer oxygen and none of the health care staff said they would cool the head of the baby. Some TBAs said they would stimulate the baby to cry by inserting their finger into its anus or tapping the baby (36%) or give the newborn an enema (4%), or lime juice (8%), or pouring water on the baby (12%).

6.3.10 Post-delivery practices: newborn breastfeeding practices

Table 6.11 shows the breastfeeding practices of maternity care providers in Ghana. There was no significant difference in the time for breastfeeding initiation or duration for attempting to achieve breastfeeding if first attempts failed between the three delivery settings. More than half the HCWs said they ensured that mothers initiated breastfeeding within 30 minutes post-delivery and if the babies could not suck on the first attempt, more than 70% of maternity care providers said they attempted after about an hour. If efforts to get the newborn to breastfeed were fruitless, 70% of hospital staff said they advised mothers to express and spoon-feed the baby and over 70% of staff in clinics and homes said they referred the baby to the nearest hospital or nutritionist. The top reasons HCWs attributed to the baby's inability to breastfeed were maternal breast complications, poor placement of the baby or congenital abnormalities. Among TBAs, the most commonly reported neonatal disease that contributed to non-breastfeeding was 'asram' (Asram is a serious disease traditionally believed to be caused by spirits and the only way to treat it is believed to be herbal concoctions (85, 153)).

Table 6.11: Breastfeeding practices

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Duration to initiate breastfeeding				
Within 30 minutes	20 (100)	22 (88)	18 (69)	0.17
>30 mins - 1 hour	0	2 (8)	5 (19)	
Within 1 day	0	0	1 (4)	
>1 day	0	1 (4)	2 (8)	
How long will you keep trying if baby does not suck at first attempt				
1 hour	16 (80)	19 (76)	16 (73)	0.34
2-3 hours	0	2 (8)	0	
1 day	3 (15)	4 (16)	6 (27)	
2- 3 days	1 (5)	0	0	
Action after unsuccessful breastfeeding attempts				
Refer to nutritionist	8 (40)	21 (84)	19 (73)	0.003
Express and spoon feed	14 (70)	14 (56)	2 (8)	0.01
Alternate feeding	2 (10)	2 (8)	0	0.31
Wait until baby breastfeeds	0	0	1 (4)	0.39
Give IV fluids	2 (10)	0	0	0.16
Give coconut water	0	0	2 (8)	0.16
Give evaporated milk	0	0	1 (4)	0.20
Possible reasons for non-breastfeeding				
Baby doesn't like breastmilk	2 (10)	1 (4)	3 (12)	0.60
Complications of breast	17 (85)	21 (84)	14 (54)	0.02
Congenital abnormalities	18 (90)	19 (76)	9 (35)	<0.001
Poor placement of baby	18 (90)	23 (92)	12 (46)	<0.001
Baby too tired/ asphyxiated	5 (25)	7 (28)	8 (31)	0.35
Prematurity/ poor suckling reflex	9 (45)	9 (36)	1 (4)	0.04
Sick baby	5 (25)	5 (25)	8 (31)	0.41

6.3.11 Post-delivery practices: newborn hygiene

Table 6.12 shows bathing practices for newborns following delivery. Bathing practices often involved exposing the babies and thus could lead to hypothermia, depending on the vulnerability of the baby or the duration of exposure. There were significant differences in bathing practices for preterm newborns between the delivery sites but not for term babies. The majority of hospital staff said they simply top-and-tailed preterm babies, but 50% of TBAs said they used soap and water. When asked about the time of first bath, almost all midwives in clinics and hospital staff said they bathed the baby after at least 6 hours but the majority (54%) of TBAs said they bathed the babies in less than 6 hours after delivery. The difference in time of first bath was statistically significant.

Table 6.12: Post-delivery hygiene practices

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Cleaning of preterm				
Use soap and water	2 (15)	2 (11)	8 (50)	0.03
Top and tail with tepid water	7 (54)	6 (32)	6 (38)	
Don't bath baby until 1 week	1 (8)	6 (32)	2 (13)	
Wipe the baby with sheet	3 (23)	5 (26)	0	
Cleaning a term baby				
Use soap and water	9 (69)	18 (95)	18 (82)	0.12
Top and tail baby	2 (15)	1 (5)	4 (18)	
Don't bath baby until 1 week	2 (15)	0	0	
Time for first bath				
Immediately	1 (5)	0	9 (38)	0.004
<2 hours	0	0	2 (8)	
2-6 hours	0	0	2 (8)	
>6 hours	9 (45)	13 (54)	5 (21)	
>24 hours	7 (35)	11 (46)	6 (25)	

6.3.12 Post-delivery review arrangements

Table 6.13 shows the review arrangements maternity care providers made with mothers before discharge. The least assessed characteristics by all groups of maternity staff were meconium and urine passage and the most assessed were breathing pattern and activity levels. The majority of hospital and clinic staff said it was the mother's responsibility to attend review, and most of the TBAs said they visited the mothers in their homes.

Table 6.13: Post-delivery care services

	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Observations before discharge				
Breathing pattern	20 (100)	25 (100)	23 (88)	0.49
Feeding habit	20 (100)	25 (100)	22 (85)	0.15
Temperature, pulse, respiration	18 (90)	24 (96)	6 (23)	<0.001
Swallowing reflex	19 (95)	25 (100)	15 (58)	<0.001
Level of activity	20 (100)	25 (100)	23 (88)	0.49
Meconium and urine passage	8 (40)	4 (20)	0	<0.001
Review arrangements				
Patient responsibility	20 (100)	23 (92)	4 (15)	<0.001
We visit them at home	10 (50)	21 (84)	20 (77)	0.02
Telephone reminder/ follow up	4 (20)	5 (20)	2 (8)	0.45
Immunisation arrangements				
Patient responsibility	15 (75)	19 (76)	15 (58)	0.52
We visit them at home	6 (30)	20 (80)	5 (19)	<0.001
Telephone reminder/ follow up	2 (10)	3 (12)	2 (8)	0.91

6.3.13 Healthcare worker self-assessment of neonatal management skills

The bar graphs in Figures 6.9- 6.13 depict how maternity care providers rated their own skills regarding management of several newborn complications on a Likert scale from 1 (very poor) to 5 (very good).

Figure 6.9: Healthcare worker skill self assessment: Neonatal resuscitation

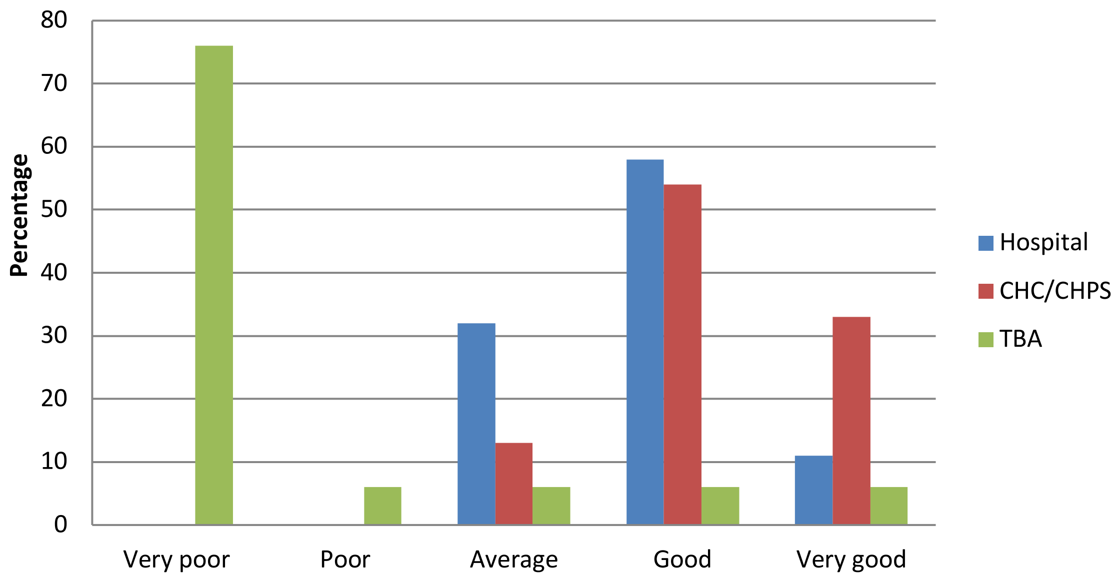


Figure 6.9 depicts how maternity care providers rated their neonatal resuscitation skills. Over 70% of TBAs rated their skill in resuscitating babies as

very poor and the majority (>50%) of midwives in clinics and hospital rated their skill as at least good.

Figure 6.10: Healthcare worker skill self assessment: neonatal infection

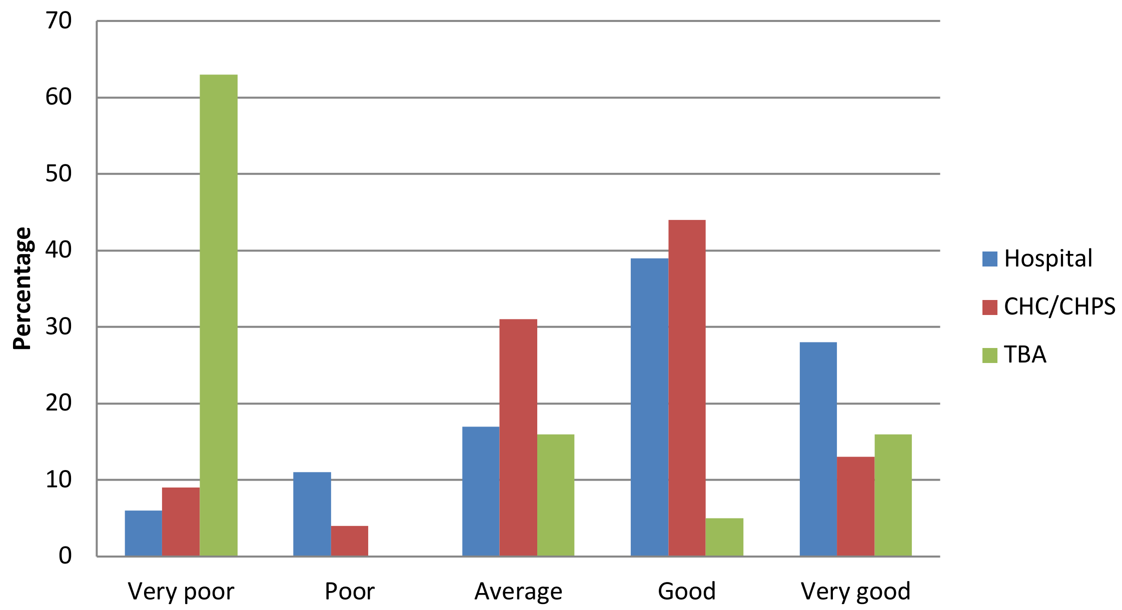


Figure 6.10 shows how maternity care providers rated their own neonatal infection management skills. Over 60% of TBAs rated their skill as very poor and more than 60% of hospital and clinic staff rated their skill as at least good.

Figure 6.11: Healthcare worker's skill self assessment: preterm baby

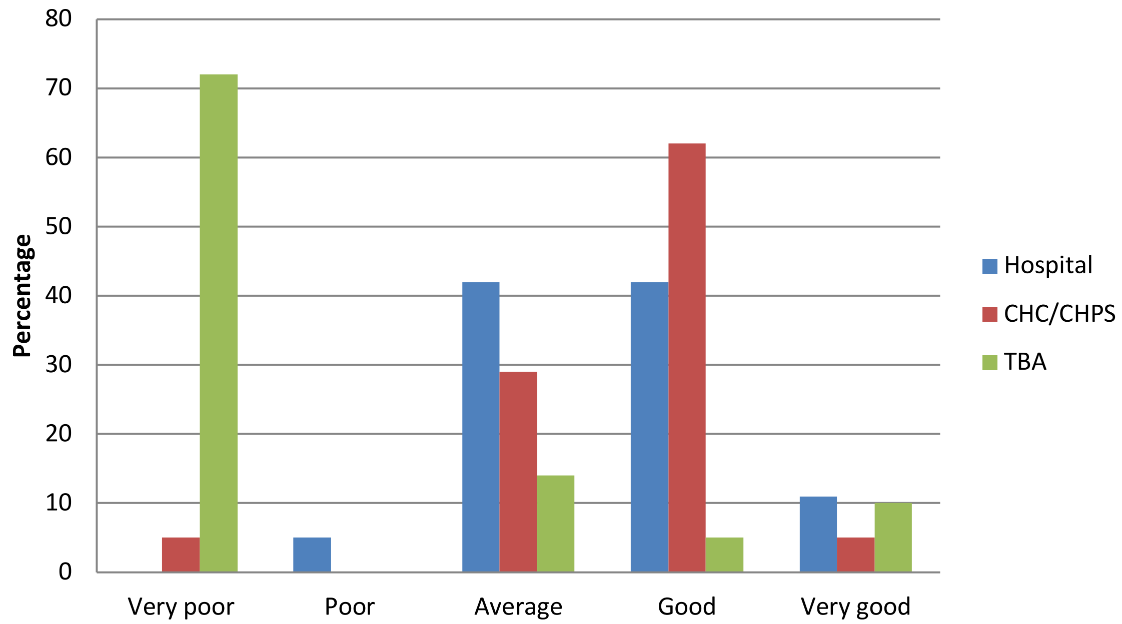


Figure 6.11 shows how maternity care providers rated their preterm birth management skills. Over 70% of TBAs in the homes rated their preterm baby

management skill as very poor and over 50% of staff in clinics and hospital rated their skill as at least good.

Figure 6.12: Healthcare worker skill self assessment: Low birth weight

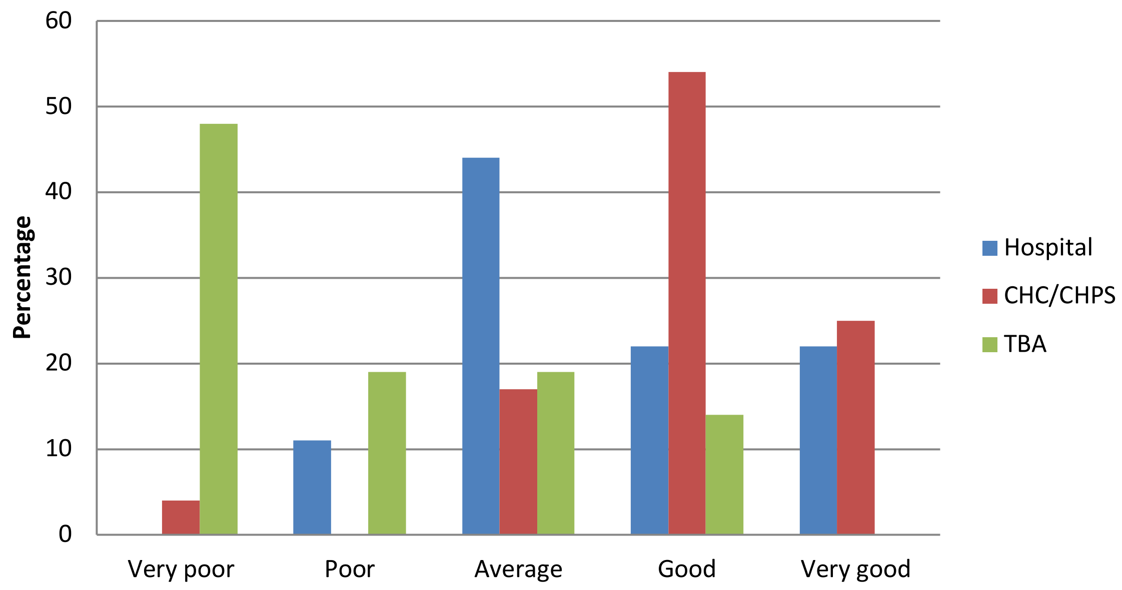


Figure 6.12 depicts how HCWs rated their skill in the management of babies with low birth weight. The graph shows that no TBA rated her skill as very good.

Figure 6.13: Healthcare worker skill self assessment: Neonatal asphyxia

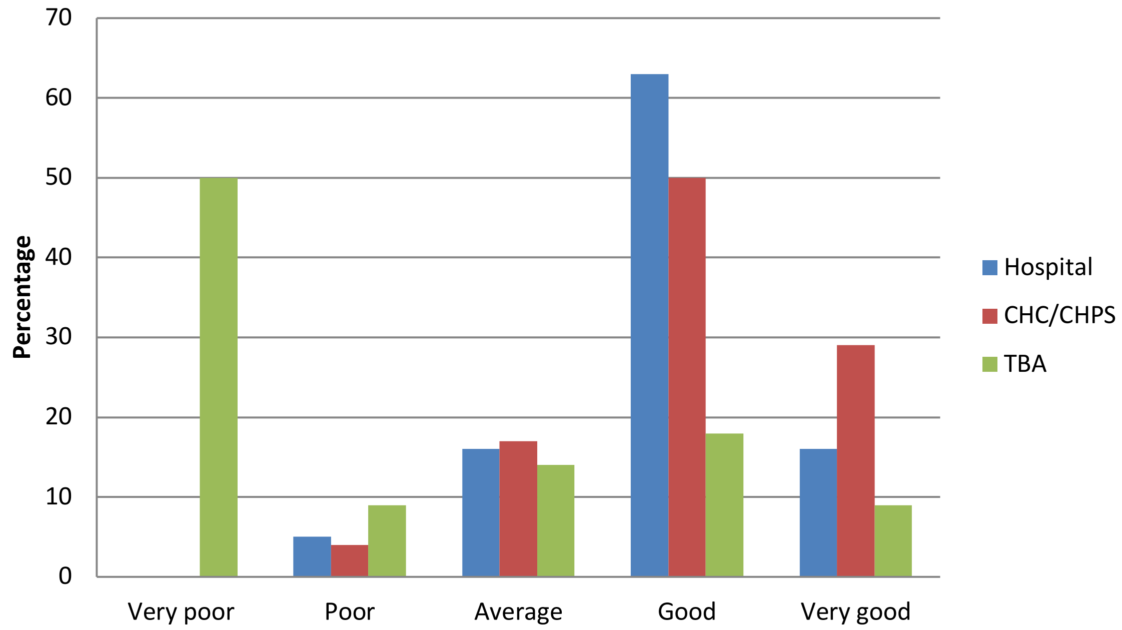


Figure 6.13 represents how HCWs rated their neonatal asphyxia management skills. Half of TBAs rated their skill as very poor and almost 80% of clinic staff and 90% hospital staff rated their skill as at least good.

6.3.14 Healthcare worker assessment of delivery facilities

Table 6.14 shows significant differences in how HCW assessed the resources in their delivery settings in terms of how well suited they were to managing adverse neonatal conditions. At least half of hospital staff said they had adequate facilities to resuscitate a baby or manage a baby with infection, but not preterm births. The majority of clinic staff said they did not have adequate facilities to resuscitate a baby or manage an asphyxiated baby. The majority of TBAs said they did not have the requisite facilities to manage any of the adverse neonatal outcomes.

Table 6.14: Healthcare worker assessment of delivery facilities

Facilities available	Hospital (N=20) n (%)	Clinic (N=25) n (%)	Home (N=26) n (%)	p-value*
Resuscitating a baby				
Adequate	10 (53)	5 (20)	0	<0.001
Not adequate	9 (47)	19 (76)	2 (9)	
Nil	0	1 (4)	20 (91)	
Management of an infected baby				
Adequate	13 (68)	3 (12)	3 (14)	<0.001
Not adequate	4 (21)	6 (24)	2 (9)	
Nil	1 (5)	16 (64)	17 (77)	
Management of preterm baby				
Adequate	2 (11)	0	1 (5)	<0.001
Not adequate	12 (63)	5 (20)	2 (9)	
Nil	5 (26)	20 (80)	19 (86)	
Management of low birth weight				
Adequate	7 (37)	6 (24)	2 (9)	0.04
Not adequate	10 (53)	11 (44)	8 (36)	
Nil	2 (11)	8 (32)	12 (55)	
Management of asphyxiated baby				
Adequate	9 (47)	3 (12)	1 (5)	<0.001
Not adequate	10 (53)	22 (88)	2 (9)	
Nil	0	0	18 (82)	

6.4 Summary of findings and Discussion

6.4.1 Characteristics of maternity care provider and type of maternity services

Two major dimensions of assessing a health facility include service users' and providers' perspectives. Assessing the characteristics of service providers, types of services available or the quality of those services from a user's perspective is limited to their recall and the type of services received (316). There are also some questions regarding service or equipment availability which cannot be accurately answered by service users. In these scenarios, assessing the providers' perspective produce more useful responses. Facility assessments from the provider's perspective could take the form of inventories, record reviews or reviews of reports, observations or interviews of care providers. The scale of these assessments, from single facility to a nationwide assessment, has implications for time and money. Previous studies in the Brong Ahafo region in Ghana have used vignette and tracer methods to assess the quality of maternity services (125) (126). This thesis adds to that work by surveying (this Chapter) and interviewing (Chapter 7) maternity care providers in three geographically distinct regions. This method was also considered appropriate because the time and resources required to observe maternity care providers over a period of time to document the types of services provided, their level of skills and quality of services and associated outcomes was not available (The limitations associated with surveys and interviews are discussed further in this section).

The survey showed that while midwives and doctors in hospitals and clinics were formally trained, most TBAs were trained by their relatives and subsequently received some limited training by the Ghana Health Service. TBAs were relatively older and had longer years of overall practice experience, compared to doctors and midwives. A previous survey of 1,226 home birth attendants in India, Pakistan, Guatemala, Congo DRC, Kenya and Zambia found similar results (77). It is safe to assume that TBAs have operated since the genesis of birthing among humans; but their activities in Ghana became somewhat formalised in the 1970s when government policies considered training them to address the issue of high maternal mortality, especially in rural areas (90, 91). The value of their training today remains controversial and plausible arguments are made both for and against it. Proponents argue that, given the high maternal and perinatal mortality rates and the proportion of births attended by unskilled attendants, training TBAs could potentially improve maternal and child outcomes (92, 93). According to them, this is one sure way of making the best use of the available human resources, in the short term, while planning long term measures to increase universal access to skilled maternity services. Such claims are however refuted by opponents who posit that if anything at all, TBAs act as 'stopgaps' by delaying the initiation of more impactful activities, and their low caseload does not justify the cost of their training (94). There is some evidence that TBAs do acquire new skills and techniques, but empirical evidence for the effectiveness of TBA training on maternal and neonatal outcomes is not compelling (95, 96). Other factors which determine whether the acquired knowledge is translated into practice include supervision and integration into formal health care systems. In Ghana, some districts like the two Kassena-Nankana districts in the Upper East region have abolished home deliveries, but the rest of the country seems ambivalent.

Unlike most midwives and doctors who are employed by the government and are thus required by law to retire by age 60 or 65 years, TBAs are 'self-employed' and so could work as old as they preferred, or until a daughter- or granddaughter-trainee was 'competent' or confident to practice. The hospitals included in this survey were district hospitals in relatively rural areas. It is therefore likely that more experienced clinicians would have transferred to the city or moved into specialised areas for which services are only available in the regional capitals. The inequity in the distribution of health workers and clinical expertise between rural and urban districts, and the factors contributing to these, has been explored previously (317-321). This survey suggested that maternity staff in hospitals conducted more deliveries on average per month, and midwives in clinics and TBAs had similar delivery output on average. This finding should be interpreted in context: it pertains to the caseload per practitioner and not necessarily the proportion of total births attended by skilled or unskilled providers. It has been shown that the majority of births in Ghana are conducted by skilled personnel, but there is wide regional variation (10).

The survey showed that on average it took less than an hour to travel between one delivery facility to the next higher level facility, and the shortest distance was between home and a clinic. It was generally easy to get a vehicle from one delivery site to another but there were some known days or times when transport was hard to access. Transport difficulties, and the distance to health facilities, are well-known barriers to accessing skilled maternity services in low and middle income countries (238, 322, 323). Although the reported travel durations between two delivery sites is not the same as the distance between a woman's home and a delivery facility, it is important because it is suggestive of how soon referrals could be. Given that home deliveries were closest to clinics, one would expect that TBAs would transfer difficult deliveries to clinics in time. Unfortunately, clinics are not well equipped to manage many birth complications and TBAs have been noted to transfer babies too late, after several trials at home (324, 325). There is an urgent need to reduce access barriers to skilled maternity care and improve emergency services, especially in rural areas. This may involve equipping clinics to manage moderate obstetric and neonatal complications, and or training community nurses and midwives to provide skilled maternity services and manage adverse birth complications at home.

There were significant differences in the type of maternity service provided, by the type of delivery setting. Hospitals provided most forms of the listed maternity services, including advanced care such as assisted vaginal delivery and caesarean section. In addition, they said they treated all types of women regardless of their obstetric risk. Clinics and TBAs only provided spontaneous vaginal delivery, and almost all clinics staff said they cared for sick mothers and babies. Although fewer TBAs said they cared for mothers and babies, it was indicated that if mothers believed that the child suffered from 'asram', they sent him or her to a TBA or traditional healer. Asram is a serious disease believed to be caused by spirits and the only way to treat it is believed to be herbal concoctions (85, 153). TBAs in this survey said they prescribed herbal concoctions for mothers but doctors and midwives did not. This distinction is very important as it suggests that women sought treatment based on their belief about the aetiology of newborn illness (154). Asram is further discussed in Chapter 7.

The differences in the type of maternity service and the risk managed by the different maternity care providers reflect the skillset of the care provider as well as the facilities at their disposal (77). In hospitals, maternity care was provided by doctors and midwives who are highly skilled (in relative terms), unlike home settings which were care was provided by TBAs with little or no formal education and have very rudimentary equipment. Yet TBAs believed that more mothers were attracted to them because they 'pampered' the mothers and provided spiritual and psychosocial support. A significant proportion of TBAs in this study intimated that they provided spiritual support for mothers in labour and they visited them in their homes following delivery. Other studies have confirmed the cultural competence, compassion and sensitivity of TBAs (85-87). In contrast, several publications highlight the poor attitude of midwives in Africa towards patients (88, 89), and some women have indicated they would not recommend the hospitals or clinics to other women (101). In the opinion of the TBAs, some women did not deliver at home simply because they preferred the alternate services, but according to midwives, women preferred their services because they were professional, they managed complications or simply because they were the only service providers in the community. It has been shown that while midwives in clinics and hospitals concentrated on 'technical aspect' of care, TBAs were more empathic and thus focused on the 'natural aspects'. Ordinarily, midwives' ability to manage birth complications would be an incentive for mothers desiring safe delivery. However, in a culture where it is believed that complications arising out of delivery is evidence of extramarital affairs, and facility-based delivery is considered a sign of weakness (78, 100), it seems counterproductive for midwives to pride themselves in their ability to manage complications. It is needless to add that maternity care need not be either technical or natural, it is both, and midwives need to combine both elements of it to make their facilities more attractive.

In accordance with the National Health Insurance Scheme and Free Maternal Delivery policies in Ghana (199, 201), there were no service user fees for deliveries in hospital or clinic. However, mothers who delivered in those facilities were required to provide a list of items which indirectly increased cost (102, 326). On the contrary TBAs charged for delivery services and also required mothers to provide similar items to those demanded in other health facilities. TBAs said that they still delivered mothers who could not afford payment at the time, or refused to come in with the required items, and they allowed mothers to pay the delivery fee in instalments or with other non-monetary items like food (327-329). There is sufficient evidence of the high cost of maternity services and the poor attitude of skilled care providers as barriers to seeking skilled services (89, 330, 331). Transparency International, the world's leading non-governmental anti-corruption agency, has classified charging fees for services which are supposed to be free as one of 37 types of corruption in the health care industry. Corruption in healthcare could mean the difference between life and death and poor people are the worst affected. Maternity care providers need to be educated on the impact and consequences of corruption (332). This could be in the form of workshops or seminars to help midwives and doctors identify corruption and ways to deal with it. Removing all cost barriers to accessing maternity services is a noble objective, but such a policy, however generous, will not thrive unless care providers are receptive and respectful.

6.4.2 Birth practices of maternity care providers

Except for neonatal death and premature birth, the majority of maternity care providers said they had experienced all the adverse newborn outcomes under consideration. The commonest adverse neonatal outcome experienced by maternity care providers in Ghana was birth asphyxia, and care providers in hospital were more likely to experience it than any other group. Care providers in hospital were also more likely to have experienced neonatal mortality and prematurity, and TBAs at home were the least likely to have experienced both. It is thus suggestive that hospitals were more likely to receive high-risk deliveries than clinics or home.

Regarding the management of birth complications, most care providers said they adhered to the majority of infection prevention measures during delivery, but there was consistently fewer TBAs than skilled providers who adhered to all the listed infection prevention measures. While all skilled providers said they used sterile equipment, washed their hands, ensured a clean environment and delivered the baby onto a clean field, some TBAs said they did not. Notably, fewer TBAs wore protective clothing including gloves or facemask during delivery. This is particularly worrisome because without using sterile equipment, or wearing gloves TBAs put themselves and mothers and babies at risk of many infections, including HIV/AIDS (333-335). TBAs and midwives in clinics said they would transfer a mother with PPROM to the hospital, but just a little over 60% of TBAs said they would transfer a woman with PROM to the hospital and the rest said they will allow her to deliver, or administer herbal drugs. In clinics and hospital, women who had active infection during labour were given antibiotics before or after delivery, but at home, less than half the TBAs said they transferred women with infections to the hospital. The majority TBAs said they simply cleaned the vaginal tract with an antiseptic solution or administered herbal medications.

Maternal bacterial colonisation, PROM and PPROM are significant risks for early-onset neonatal infections(336, 337). It is plausible that swabbing the birth canal with antiseptic solution could reduce the number of pathogens causing infection and a previous trial in Malawi found that cleaning the birth canal with 0.25% chlorhexidine during each vaginal examination prior to delivery, as well as wiping the baby with the chlorhexidine resulted in significant reductions in overall neonatal admissions (16.9% vs 19.3%, $p<0.01$), admissions to infections (7.8 vs 17.9) and NMR due to infections (2.4 vs 7.3, <0.005)(338). Among mothers who received the intervention, there was a marked reduction in maternal admissions (29.4 vs 40.2 per 1,000 deliveries, $p<0.02$) and admissions due to postpartum infections (1.7 vs 5.1 per 1,000 deliveries, $p=0.02$) (338). Further studies are required to investigate if the cleansing solution used by TBAs or the process and dosage of washing lead to any significant reductions in neonatal mortality due to sepsis. Washing the birth canal is, however, contraindicated in preterm births, second stage labour and placenta praevia (338). Without the necessary skills or equipment, TBAs may not be able to assess risks for vaginal washing and thus put mothers at increased risk. Babies could become infected before labour due to vertical transmission from the maternal perineum. Douching has also been found to be associated with pelvic inflammatory disease and vaginosis and it is strongly discouraged during pregnancy (339). Recommended treatment for maternal infection involves antibiotics - penicillin, ampicillin, cefazolin or clindamycin- at least four hours before delivery (340).

Infection is one of the leading causes of neonatal mortality globally, and in Ghana it is the leading cause of death at home (57, 341). A newly cut umbilical cord is an easy pathway to inoculate bacteria and so optimal cord hygiene is encouraged. As noted in previous studies, this survey showed that a significant proportion of TBAs treated the umbilical cord stump with various substances including shea butter, sand, salt, toothpaste and white chalk, whereas almost all skilled care providers treated the umbilical stump with methylated spirit (80, 159). Treating the umbilical cord stump with non-sterile solutions is a significant risk for late onset sepsis, including tetanus caused by *Clostridium tetani* which is found in soil (342). Preterm or very low birthweight babies are most affected due to reduced immunity (343, 344). Current recommendations for cord treatment is the use of 7.1% chlorhexidine digluconate or 4% chlorhexidine, especially in countries with high home births and NMR>30 (345, 346). In countries with NMR<30, chlorhexidine has not been found to reduce neonatal mortality any significantly (347, 348). It was interesting to note that when midwives did not have methylated spirit, they did not apply anything, but TBAs always applied something. This stems from a desire to cause early separation or healing (349) and so TBAs went all out to try everything, be it healthy or not. Until clearer policy guidelines for cord care are developed, it is advised that antenatal education discourages mothers and their care givers from applying unhealthy substances to the umbilical cord.

All maternity care providers in hospitals and clinics assessed newborn babies using the APGAR scoring system (350), and the majority of TBAs assessed most elements of the APGAR system, except pulse and grimace. During labour, all midwives did a complete assessment of the mother and progress of labour was monitored using a partograph. On the contrary, the majority of TBAs did not assess fetal heart rate or time the contractions of the uterus. Without appropriate assessment and documentation of labour progress, TBAs will not be able to detect changes in vital statistics and consequently delay in identifying babies who may be undergoing distress, with its accompanying complications (Low et al., 1994; Graham et al., 2008). Birth asphyxia was managed by suctioning and resuscitation in hospitals and clinics, but the majority of TBAs in homes referred such babies. In severely asphyxiated babies, treatment may involve setting up intravenous infusions for electrolyte control and to improve cardiac output, oxygen or mechanical ventilation, and appropriate drugs if neurological effects set in (351). Clinics in this study did not have a NICU and the hospitals which had were not fully equipped. This survey could not estimate how soon babies who suffered asphyxia were transferred, but with an average of 30 minutes between home delivery settings and clinics, asphyxiated babies could develop complications before appropriate help was received. Among TBAs who did not refer such babies, only one said she would resuscitate the baby and others used crude measures to stimulate it, including pouring water on the baby, inserting their finger into the baby's anus or tapping it. Most of the TBAs did not have an ambu-bag to resuscitate asphyxiated babies or equipment for suction. Given that asphyxia was the commonest complication experienced by TBAs, and indeed all maternity care providers, it would be helpful to train them regarding basic life support for newborns as well as provide them with equipment for resuscitation.

Preterm deliveries were mostly managed in hospitals, and most clinic midwives and TBAs said they transferred preterm babies to hospitals. Without a weighing scale to measure birthweight or knowhow to assess early booking scan, TBAs could find it difficult to diagnose babies who were preterm, especially active preterm. The priorities for managing preterm babies in hospitals were maintenance of body temperature, infection prevention and nutrition. Only 50% of hospitals included in this survey had an incubator and pulsimeter and none of them had a paediatrician or neonatologist. Preterm birth is one of three leading causes of neonatal death globally and in Ghana (57, 352). The long term complications among preterm babies who survive the neonatal period are also well known (353, 354). With advances in medical technology, the proportion of preterm deliveries in developing countries is likely to increase, as they have in developed countries (271). Reducing the rate of preterm birth could be a future objective, but improving the survival of preterm babies using existing strategies is more pressing. This involves improving NICU facilities in hospitals and staff training in the management of preterm births should be a policy priority. Other primary, secondary and tertiary interventions to reduce morbidity and mortality associated with preterm birth have been published (268). There were also significant differences in the time for initiation of bathing, especially for preterm babies. In health facilities, term babies were bathed after at least 6 hours and preterm babies were top-and-tailed, but TBAs said they bathed babies soon after delivery using soap and water. Early initiation of bathing, unfortunately, could expose the baby to cold which is a known risk of death (79, 310).

On a positive note, it appears that education regarding the benefits of early initiation of breastfeeding is well accepted by all maternity care providers in Ghana (232), but there were significant differences in alternative feeding options if initial breastfeeding attempts failed. While most midwives in clinic and hospital said they would express and spoon feed or refer the baby to a nutritionist, it was surprising to learn that a few TBAs said they gave evaporated milk products or coconut water. There is no need for a clinical trial on the effectiveness of coconut water as an alternate feed for babies as it is unlikely that 1.3 grams of sugar, 61mg of potassium and 5.45mg of sodium contained in an ounce of coconut water is healthy for a newborn. TBAs need to be sensitized to refer babies who are unable to breastfeed to a nearby clinic or hospital. In a self-assessment of their own skill in managing birth asphyxia, prematurity and infection, the majority of TBAs rated their skills on all three as very poor and the majority of clinic and hospital staff rated their skill on all three as at least good.

Newborn complications are poorly managed at home, and it appears the odds of neonatal mortality increase with the number of risks associated with the delivery. Assume a hypothetical scenario of a mother with PPROM precipitated by an active infection who is being delivered at home. This preterm baby could receive an early bath following delivery, and then his or her cord stump dressed using sand. In the likely event that this hypothetical baby develops infection within three days of birth (355), he will be given herbs because the illness is believed to be caused by asram. Indeed, except for a miracle, it will be “easier for a camel to go through the eye of a needle” than for this hypothetical child to survive past the neonatal period. Such a stark example of the avoidable painful death this baby could suffer is frightening, but to think of the worst possible scenario associated with clinic or hospital birth is less scary. It is important to emphasise facility-based deliveries, but even more for sick babies to be managed by skilled professionals. In-depth interviews of how maternity care providers managed specific cases of birth complications are presented in Chapter 7.

6.4.3 Conclusion

This survey showed statistically significant differences between the skillset, equipment and birth practices among maternity care providers in Ghana. TBAs, although often experienced, were less educated, had insufficient equipment or capacity to manage birth complications and some of their activities predisposed babies to infections rather than reducing risk. Their strength was in their cultural understanding and provision of spiritual and emotional support which attracted women to their practice. Midwives in clinics had the necessary education and basic equipment to manage uncomplicated birth asphyxia only. They did not have equipment to manage advanced asphyxia, drugs for infections or incubators to manage preterm births. Clinic staff therefore referred babies with conditions they could not manage to the nearest hospital but transfer could be marred by transport challenges. Only hospitals had the capacity to manage all the listed types of newborn complications. However, hospitals involved in this survey lacked a specialist paediatrician or neonatologist and their NICU was substandard. Skilled birth attendants in hospital and clinic focused on the professional aspects of delivery, but were described as being mean towards women, making their services unattractive. Other barriers to skilled birth attendance, including the cost of service and transportation, have been described. Skilled delivery by a skilled practitioner in a safe environment is essential for achieving optimum maternal and neonatal outcomes. However, skilled birth practices ought to be delivered in a culturally sensitive, mother-friendly environment to make it attractive to women.

6.4.4 Strengths and Limitations

Perceptions that home deliveries are a risk for newborn deaths are common but no study in Ghana has explored the characteristics of maternity care providers or the differences in services provided by the various delivery settings. Previous health facility assessments were restricted to care providers in the formal health sector (i.e hospitals and clinics) (125) or a single region (126). This survey describes the characteristics of maternity care settings in Ghana and birth practices in the various delivery settings in three regions Ghana. It helps us understand the conditions in which they provide maternity services to women and how this could potentially contribute to neonatal mortality. It used a mixed methods sampling approach, involving a combination of probability and non-probability techniques, to select a reasonable proportion of experienced care providers from each type of maternity setting. This helped ensure that the information collected was accurate and truly reflected reality. I believe accuracy of information is paramount. However, the sample of these care providers is, strictly speaking, not statistically representative and so the results should be interpreted or generalised with some caution. A cross-sectional study of this nature cannot show effects of place of delivery or birth practices on neonatal mortality. A sample size of 71 maternity care providers is also too small to detect significant associations in multivariable analyses. In the current study, nonetheless, it was sufficient to select 48 care providers who experienced adverse newborn outcomes for in-depth interviews (Chapter 7).

One of the common problems with surveys is the inability to validate the accuracy or ascertain the veracity of information provided by the interviewee, or how much thought has gone into the response. For example, midwives in hosptials may have indicated that they had the equipment This was less of a problem in the current survey because I sampled experienced maternity care providers (>2 years) in the maternity units and used multiple sources of information for each type of delivery setting. The survey was conducted among doctors, midwives and TBAs, but I selected midwives as research assistants. These midwives were selected because of their language skills and their understanding of the research area. It could be argued, however that this could potentially bias interviews or questionnaire administration, especially to their colleagues. It was therefore ensured that research assistants administered questionnaires to TBAs only. These research assistants were also trained on the research objectives, ethics and principles of research. The questionnaire was highly structured and thus left little room for research assistant's personal interpretations. Following each interview, I discussed with the midwife research assistant what she thought of the survey, and all perceptions were clarified. This process of reflection helped the researcher and assistant reflect the research process, personal feelings and thus improved the surveys. Interviewees were also allowed to ask any questions or suggestions they had at the end of each survey.

Chapter 7 In-depth interviews of maternity care providers in Ghana

7.1 Introduction

Following the questionnaire survey of maternity care providers in Chapter 6, doctors, midwives and traditional birth attendants (TBAs) who said they previously managed a baby with birth asphyxia, neonatal infection, prematurity or neonatal death were interviewed to understand the context in which the deliveries had been conducted or newborns cared for, and to explore cultural and birth practices which could potentially influence neonatal mortality in Ghana. These in-depth interviews form the *qual* phase of the overall mixed methods study (Chapter 3). This chapter presents the methods and results of these in-depth interviews with maternity care providers in Ghana.

7.2 Methods

7.2.1 Sampling and recruitment

Details of the methods used to sample maternity care providers for the questionnaire survey have been described in Section 6.2. Care providers (n=71) involved in the survey (Chapter 6) served as the sampling frame to select 48 doctors, midwives and TBAs for in-depth face-to-face interviews. This number was based on an attempt to have at least 12 maternity care providers for each type of delivery setting and on-the-ground practicalities during the field work (356, 357) (Table 7.5.1). Maternity care providers were purposively selected based on their experience of any of the predetermined adverse neonatal outcomes: birth asphyxia, neonatal infection, premature birth and neonatal mortality. These adverse outcomes were chosen because they have been identified as the major causes of neonatal mortality in developing countries (5, 57, 59).

7.2.2 Data collection procedure

With the aid of a semi-structured interview guide (Appendix 3.4), maternity care providers were asked to recall and describe their most recent experience of any of the adverse neonatal outcomes. Questions pertained to the circumstances around the experience, the care providers' interventions and the outcomes.

Appropriate follow-up questions were asked to clarify emerging concepts or themes. In addition, photographs were taken of the environment within which care was provided as supportive evidence, especially of the contextual elements of care, and also to aid explaining the findings.

Interviews of doctors and midwives were conducted in the hospital or clinic and interviews with TBAs were conducted in their homes. Most interviews were conducted immediately after the questionnaire survey but a few interviews of midwives had to be rescheduled because of clinical emergencies in the health facility. The interviews with doctors and midwives were conducted in English and those with TBAs were conducted in the appropriate local language (Kintampo- Akan/Twi, Dodowa- Dangbe, and Navrongo- Kassem). The TBA interviews in each HDSS were assisted by the research assistant responsible for that region. These research assistants, who were midwives, were selected based on their language proficiency. To reduce the possibility of bias during interviews with TBAs, I ensured that I was present throughout all the interviews, and the research assistants were trained in the use of an interview guide and the research ethics. The interview guide was also semi-structured and left little room for the research assistants to ask other questions. The criteria for selecting research assistants have already been described in section 6.2.6. At the end of each interview, I discussed the process and the responses of the interviewees with the research assistant to ascertain her observations and thoughts on the interview section. These post-interview discussions were especially helpful for the research assistant-led interviews in Dangbe. It gave me a preliminary understanding of what was discussed and also offered me the opportunity to evaluate the interview, and make suggestions to improve subsequent ones.

In the Navrongo HDSS, TBAs had been banned from conducting deliveries therefore only one TBA was interviewed to confirm this and to share her current duties. This implies that TBA's opinions expressed in this study are for those in Kintampo and Dodowa only. Doctors and midwives were not rewarded for participation but TBAs were given a large bar of soap (cost £6.00) as a token of thanks. This is culturally acceptable and was also recommended by the collaborating institutions. Overall, interviews lasted 15 to 60 minutes. The difference in time span for interviews was dependent on the number of adverse experiences a care provider shared; those who experienced all the four types of adverse newborn outcomes required more time, and those who experienced fewer adverse outcomes spent little time. Details of the characteristics of maternity care providers and the number of adverse neonatal outcomes they had experienced are shown in Appendix 4.1.

Fig 7.1 Photograph from fieldwork in October 2015 showing interview with TBA, Ghana (*Face has been concealed*)

Fig 7.2 Photograph of researcher (middle) with community midwife (left) and community health nurse (Right) in Ghana during field study in Ghana, October-December 2015.

7.2.3 Research governance

In addition to the overall ethics approval granted for this study (section 4.2.3), eligible interviewees were requested to give consent to participate in the interviews and for their voices to be recorded, after all necessary information regarding the purpose of study, risks and benefits, rights of participant and guidelines for managing data and audio records in the Information Sheet (Appendix 3.1) were explained in an appropriate language. All eligible maternity care providers gave full consent. The methods and tools used for the in-depth interviews were previously approved by the Scientific Review Committees and Institutional Ethics Boards of the various health research centres (Appendices 1.1-1.7). The interviews were held between October and December 2015.

7.3 Data analyses

Audio files from the interviews were downloaded onto a password protected computer, and all interviews were independently transcribed by two people to ensure that no important information was missed. Interviews conducted in English were transcribed by the researcher and a research assistant; interviews conducted in Dangbe were translated and transcribed by the research assistant for the Dodowa area and a professional translator at the Dodowa health research centre; and interviews in Akan were translated and transcribed by the researcher who is a native speaker and the research assistant for Kintampo area. All interviews were transcribed verbatim but the identities of persons or institutions were masked. Unique codes were assigned to each interviewee depending on the health care cadre (TBA- Traditional birth attendant, MWH- Midwife in a hospital, MWC- Midwife in a clinic, MD- Medical doctor), the region of practice (B- Brong-Ahafo-Kintampo, G- Greater Accra-Dodowa), and a number corresponding to the *nth* interview.

Qualitative data were analysed using the five stages of framework analysis: familiarisation, identification of a theoretical model, indexing, charting and mapping, and interpretation (358, 359). First, I immersed myself in the data by transcribing all interviews conducted in English and Akan, and re-listening to all interview audiotapes. I kept a journal of my impressions and early thoughts while reading the transcripts which informed my reflections and coding later. Next, I coded about eight of the transcripts line by line to identify emerging themes. Following that, a pre-identified conceptual framework (1) was applied to all the transcripts and I charted them against the constructs from the framework. Although this latter coding was more deductive, the former open coding allowed me to observe that important aspects of the data were not addressed in the conceptual framework (360). My final analytical framework therefore included extra constructs not previously identified in the Mosley and Chen (1984) model (1) (Details discussed later). Through a process of constant comparison, I compared codes across cases to refine the themes. Finally, connections and relationships were mapped out between codes and an explanation of the data was discussed, within the broader context of the conceptual framework. Anonymised quotes from interviewees were used to illustrate sub-themes and overarching themes. Where quotations required local understanding of the context, appropriate explanations were given and where the views of interviewees were rare, I indicated that it was distinct.

It would be naive, even deceptive, to suggest that the process of analysing and writing interview results was straightforward. A more accurate description will be a back and forth process between analyses and writing, as I went back to the interview transcripts to look for more evidence in the face of a new theme. I found framework analysis very useful in analysing the interview data because the main research question sought to explore birth practices among maternity care providers. This falls within Ritchie and Spencer's (358) contextual and diagnostic typology of research questions. They believe a framework analysis addresses four types of questions: contextual, diagnostic, evaluative and strategic. The framework analysis technique also provided an organised, systematic, flexible, transparent and rigorous approach to viewing qualitative data, especially for a first-time qualitative researcher. These qualitative analyses were computer assisted using QSR NVIVO® software for qualitative analyses (version 10).

7.4 Conceptual framework

7.4.1 The Mosley and Chen (1984) model for child survival

The Mosley and Chen (1984) proximate and socioeconomic model for child survival was chosen as a suitable analytical framework for understanding the factors associated with neonatal mortality in Ghana (1). This is because their model captures both exogenous (family/societal, environmental and socio political) and endogenous factors (biological/individual). The Mosley and Chen model has also been adapted to suit other areas in maternal health (361), neonatal health (362, 363) and HIV/AIDS (364). Although more recent models of neonatal or child mortality have been developed, their foundation can still be traced to the Mosely and Chen model (363) or were more focused on interventions rather than risk factors or not exclusively to neonatal or child mortality (365). Therefore, I decided to use the original Mosley and Chen model and adapt for use in this thesis. Previous conceptual models that sought to explain mortality among children and the policies they led to were biased along disciplinary lines (366, 367). Social scientists focused on the social determinants of health and medical scientists focused on biological mechanisms of diseases (Fig 7.3). Mosley and Chen were among the first to propose a multidisciplinary framework for child mortality (Fig 7.4) which incorporated both social and biologic causes of child mortality and their concept paper has enjoyed wide applicability (363). The Mosley and Chen model focused on children aged under five years, therefore this thesis has adapted their model to suit newborns (<28 days) which is the current population for this study. It is hoped that the adapted model shown here will provide a new perspective for understanding and improving newborn health in a developing country context.

Mosley and Chen hypothesise that “social and economic determinants of child mortality operate through a common set of biological mechanisms, or proximate factors to exert an impact on mortality”(1) (p.140). They propose that background socioeconomic determinants affect child health through five categories of 14 proximate factors (Fig 7.4). These are maternal factors (age, parity, and birth interval), environmental contamination (air, food, skin, soil, insects), nutrient deficiency (calories, protein, micronutrients), injury (accidental, intentional) and personal illness control (personal preventive measures). The dependent variable in the Mosley and Chen model was child health, measured as five categories of weight-for-age: healthy, grade I, grade II, grade III and dead. The use of weight-for-age as the outcome measure of child health status was novel because it was the first to incorporate both mortality and morbidity measures into a single variable.

In this study the dependent variable, neonatal mortality, is dichotomised as dead or alive. This is not simply because mortality is easy to measure, but because of its practical relevance to the current topic and the context. In the Mosley and Chen study, child health was measured over a period of five years and so weight-for-age may have been an appropriate variable. In the current study, however, neonatal health is measured over a 28-day period and thus marked changes in baby’s weight may not be observed (368). Secondly, birthweight is not readily available for all babies born in Ghana especially those born at home and thus the use of birthweight would have limited application. Details of the Mosley and Chen model are published elsewhere (1). I discuss my adapted framework in the light of current findings later in this chapter.

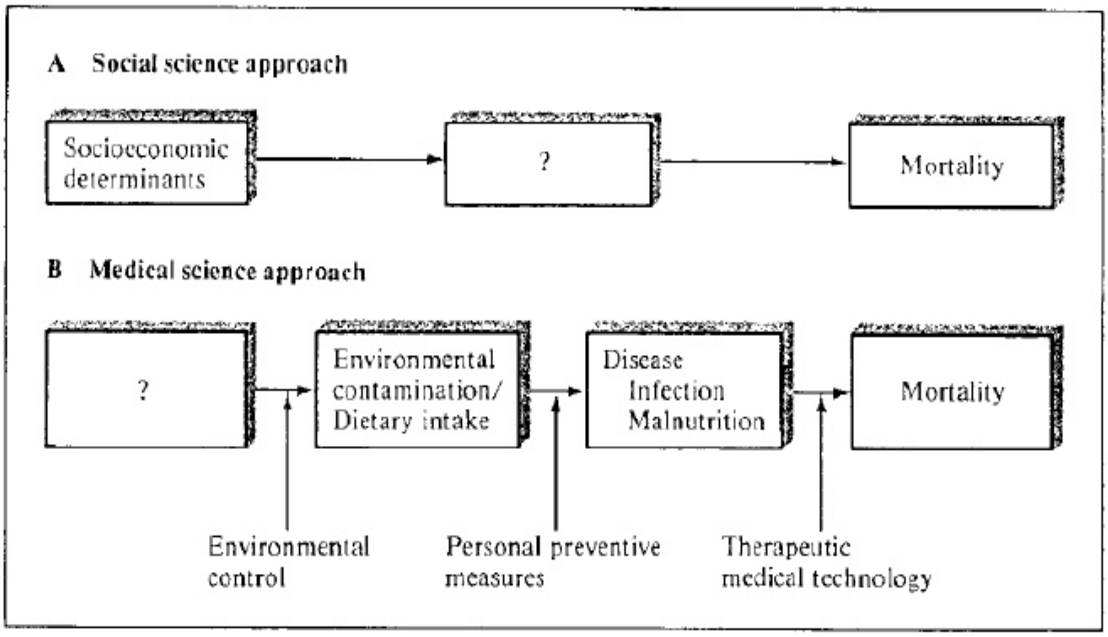


Fig 7.3: Conceptual models of social and medical science approach to research on child survival (From Mosely and Chen, 1984) (1)

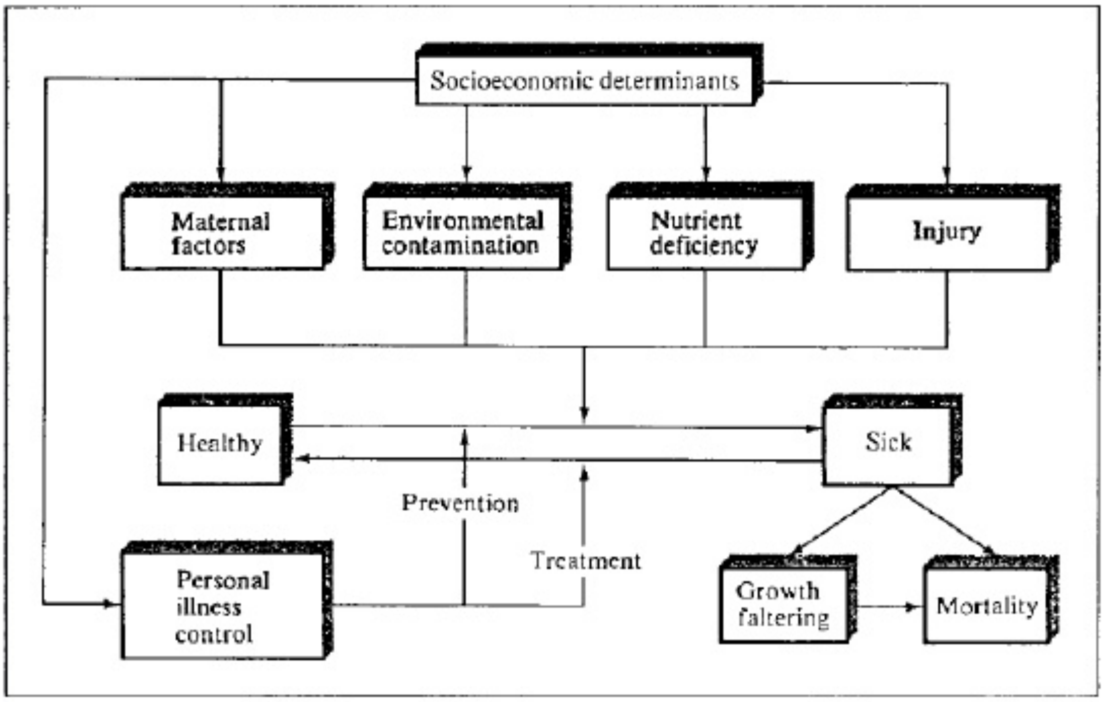


Fig 7.4: Operation of the five groups of proximate determinants on the health of a population (The Mosley and Chen proximate determinants model)

7.4.2 A conceptual framework for neonatal mortality in Ghana

The considerable body of evidence which emerged following the Mosley and Chen's (1984) model has identified other factors associated with neonatal deaths and clearer understandings of the pathways to newborn deaths have emerged. A notable absence in the Mosley and Chen framework is the effect of where mothers seek maternity services. Many recent studies in developing countries have shown that delivery by skilled health professionals may reduce the risk of neonatal death (43, 44, 98). Secondly, the authors do not identify specific etiologic causes for neonatal deaths (5, 57). Lastly, Mosely and Chen assume that all proximate factors are on the same level but it is now considered that some proximate factors are more 'direct' than others, or some proximate factors are nested within broader ones. For example, prematurity is considered a more direct cause of neonatal death than maternal education. Mosley and Chen (1984) created room for the development and improvement of their model by stating the "key to the model is the identification of a set of proximate determinants, or intermediate variables, that directly influence the risk of morbidity and mortality". Consequently, this study has adapted and updated the Mosley and Chen (1984) analytical framework, based on my research findings, to provide a holistic perspective, and a more complete understanding of neonatal mortality in Ghana (Fig 7.5). A rigorous and reliable analytical framework is the foundation for designing appropriate interventions to improve newborn health (369). I believe this framework could be transferred to other developing countries with similar socio-political and cultural structures.

The framework proposed in this thesis suggests that neonatal mortality is a product of a complex 'bio-social interaction', and rarely is it an isolated process. Like the Mosley and Chen (1984) model, this framework shows that at the first level, societal factors (Level 1) operate through basic proximate factors to affect newborn health. Although ideologically similar, the constructs inclusive of what comprises proximate factors and their level of influence in this thesis differs from the Mosley and Chen model. This thesis suggests three levels of the proximate factors: individual and family factors (Level 2), place of delivery and providers of care (Level 3) and direct causes of death (Level 4). The importance of hierarchical models in understanding the determinants of health has been discussed elsewhere (369). Although this thesis proposes that societal factors on one level affect neonatal mortality through proximate factors on lower levels, it is also possible for the societal and proximate factors on the same level to interact and affect each other. From here on, the factors being discussed are coded to correspond to, and navigate, the model (Fig 7.5).

Wider societal factors (Level 1), including cultural (L1a), economic (L1b), physical (L1c) and health care systems (L1d), work through individual and family factors (Level 2) to influence where mothers seek maternity services (Level 3). The individual and family factors (L2) include maternal demographic characteristics (L2a), health seeking behaviours (L2b), access related factors (L2c) and beliefs and attitudes towards care providers (L2d). There are three main types of place of delivery in Ghana (Level 3) - Hospital (L3a), clinic (L3b) or home (L3c). In Ghana, the place of delivery is synonymous with the type of maternity care provider who cares for women and children. Deliveries in hospitals are managed by a team of doctors and midwives, clinics are managed by midwives or nurses, and home deliveries are managed by TBAs. The type of maternity care provider at the health facility consequently influences how birth and neonatal complications (Level 4) are managed and the outcome of which may lead to neonatal death. The leading causes of neonatal deaths in Ghana are prematurity and low birth weight (L4a), birth asphyxia (L4b), infection (L4c) and congenital malformations and others (L4d). Details of the adapted model are provided in Fig 7.5. These constructs and the relationship between them served as the framework for analysis of the interview data.

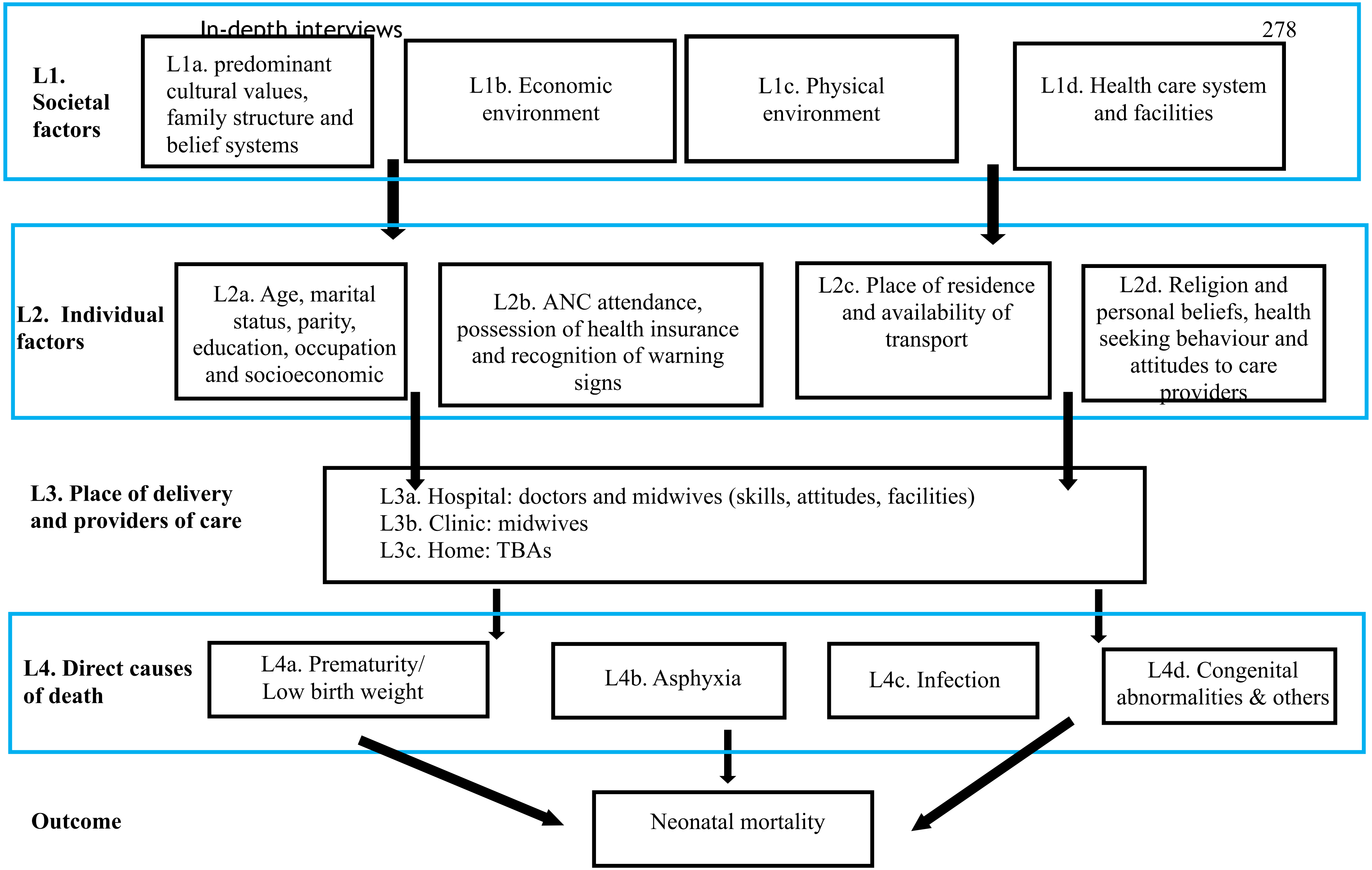


Fig 7.5: A conceptual framework for neonatal mortality in Ghana

7.5 Results

This section presents the results of a framework analysis of in-depth interviews with maternity care providers in Ghana. The aim of the interviews was to provide an understanding of the context for neonatal mortality in Ghana; a) to explore how birth management practices differ among maternity care providers in Ghana and how these affect neonatal mortality and b) to explore which societal and underlying factors affect these birth practices. Given that the interviews were conducted among maternity care providers only, all opinions about women and mothers here are a reflection of the views of their care providers. The results show that neonatal mortality in Ghana is largely influenced by where the baby was delivered or received care during illness. The place of delivery (or where care was sought from) was in turn influenced by a combination of societal factors (cultural and belief patterns, environmental and economic factors and health care system factors) and underlying factors (including maternal demographic factors, health care seeking behaviour, family and personal beliefs, attitudes and perception towards care providers, and place of residence and availability of transport). The results also show it is possible for these latter factors which influence place of delivery to directly affect neonatal mortality, without going through a health service. Details of these factors have been summarised in an adapted conceptual model which is discussed later (Fig 7.5). But first I present the 'data'- findings.

7.5.1 Characteristics of maternity care providers

Overall, 48 doctors, midwives and TBAs were interviewed. Of these, 12 worked in hospitals (5 doctors and 7 midwives), 18 in clinics (17 midwives and 1 community health nurse) and 18 at home (TBAs). The majority of the interviewees (n=40, 83%) were females and only 8 (17%) were males (5 doctors, 2 TBAs and 1 community health nurse). The hospital staff included in the interviews said they had practised in their region between 6 months and 29 years; clinic staff said they had practised between 1 and 31 years; and TBAs said they had practised for 1 to 50 years. Thirty-nine maternity care providers said they had experienced birth asphyxia (12 hospital, 12 clinic and 15 home), 28 said they had delivered a premature baby (11 hospital, 11 clinic and 6 home), 28 said they managed a neonate with an infection (8 hospital, 13 clinic and 7 home) and

18 said they had experienced a neonatal death (5 hospital, 6 clinic and 7 home). Table 7.5.1 summarises the characteristics of interviewees by health care cadre, number of years of practice and type of neonatal experience.

Table 7.5.1: Summary characteristics of care providers by delivery setting

	Hospital (n=12)	Clinic (n=18)	Home (n=18)	Total (N=48)
Region				
Navrongo	4	6	1	11
Kintampo	3	2	6	11
Dodowa	5	10	11	26
Sex				
Female	6	18	16	40
Male	6	0	2	8
Experience				
Asphyxia	12	12	15	39
Prematurity	11	11	6	28
Infection	8	13	7	28
Death	5	6	7	18
Experience (years)				
5 or less	8	8	3	19
6-10	2	7	2	11
11-15	1	1	1	3
16-20	0	0	3	3
20 or more	1	2	9	12

7.6 Societal factors influencing place of delivery (Level 1)

7.6.1 Childbearing beliefs differ among maternity care providers (L1a/L3abc)

Childbearing beliefs differed significantly between maternity care providers in Ghana. Midwives and doctors in hospitals and clinics saw childbirth as a physical event whose outcome was determined by, among other things, how the delivery process was managed and therefore they sought to understand the causes of adverse outcomes. On the contrary, TBAs had a spiritual or metaphysical perspective to childbirth. They considered childbirth to be a mysterious process whose ultimate outcome was determined by the supernatural or the child's destiny. According to TBAs, *"child birth is according to the plans of God"* (TBA Q70) and the gods gave life to the child and took back children they liked.

> *"When he screams before we know the child is ours, but if he doesn't change* [is unresponsive] *then we know the child isn't ours* [he is for the gods]*"* (TBA B11 69).

According to the TBAs, some children were messengers or spirits who carried special messages to the world and others had simply come to cause trouble.

> "*If you are coming to this world and you are a good child, we would welcome you warmly but if you are not a good child, then you would have to go back* [die]" (TBA B5 63).

The 'good and normal human child' who had intentions to *"come and eat"* (TBA Q70) was one with all the expected characteristics, according to TBAs, and the delivery process was uneventful. "Come and eat" is a local Akan euphemism for a child who has come to live or stay. In contrast, eventful or difficult deliveries or babies with anomalies that TBAs were unfamiliar with were considered non-human children and were likely to die after birth. TBAs therefore rarely sought to understand why a newborn died or took responsibility for it- it was often "*the will of the gods*" or "*the child's destiny*".

> "*After the baby came out of the womb, I passed my hand through the mouth and I realised there were teeth in mouth of the baby… And I said the baby couldn't stay… So the child was alive and died after only one week.* […] *It was because of the teeth. Oh yes because he was not human. He wasn't a proper child. Have you ever seen a newborn baby who begins to grow teeth right after he was born? As for the extra digit on the hand, it is usually there, and I am able to tear it off"* (TBA B5 63).

Eventful deliveries caused by prolonged labour were also believed to be caused by unconfessed sins of the mother. TBAs believed that infidelity or having extra marital affairs could lead to a difficult delivery and until the labouring woman confessed these 'sins', she was likely to lose her baby or even her own life.

Babies who were unresponsive at birth were also not considered human until they cried out, in which case TBAs said "*have turned into a human*" (TBA B11 69). Some babies were also believed to be reincarnated and some children were believed to have special demands, and unless these requests were met or the needed rituals were performed these children would "*return to where he came from* [die]*"* (TBA B7 71). TBAs in homes therefore performed these rituals or allowed mothers to perform the needed rites which could involve tying a red band around the wrist of the baby or putting a necklace with a coin locket around the neck of the child. The observances of these rites were believed to prevent the babies from dying. In the hospitals and clinics, however, doctors and midwives did not share in these beliefs and thus birth complications were managed using available medical technology.

7.6.2 TBAs and older family members promote cultural practices that are dated and potentially harmful (L1a/L3abc)

The use of alternative medicine for obstetric and neonatal conditions is common in many Ghanaian homes, either alone or complementary to orthodox medications. It is believed that every pregnant woman needs to use '*abibiduro*' (local medicine) in order to make her strong throughout pregnancy and those who refused made themselves and their babies vulnerable to all sorts of diseases. Fifteen of the 18 TBAs interviewed said they prescribed herbal concoctions for mothers during pregnancy or labour. The TBAs who did not prescribe herbal concoctions were more educated or had some medical experience: one doubled as a professional teacher, and the other two worked previously as auxiliary midwives in a private clinic. Women travelled from all over the region to collect these herbal concoctions from TBAs or traditional healers who are believed to be very knowledgeable about them.

> *"Yes, they come here for the herbs. I boil the herbs here by myself and fetch the juice into a gallon for them. They take it in the morning, afternoon and the evening. They fetch about 3 spoons full into a cup and take it each time"* (TBA G23 46).

Most TBAs prescribed the herbs to hasten delivery, and the effects of these are discussed later, and to help heal the 'wounds' in the womb postnatally. There were some conditions, for example those of spiritual origins, which was believed could only be treated with herbal medications, and other women resorted to herbal medications when they felt orthodox medications were ineffective.

> "*There is an example of a woman from Somanya who said she had been pregnant for two solid years, but never gave birth but you could see that*

> *she was pregnant. So somebody showed her my place and I gave her some drugs* [herbal medicines]" (TBA G24 45).

According to the TBAs, babies, especially boys, needed to have herbal baths or drink some of the herbal preparations to make them '*stronger*' (TBA Q60) or to '*protect them* [babies] *from diseases*' (MWH Q55). In some cultures too, a herbal bath was a sign of identity and initiation or welcoming into the family. It was believed that children of the same father had to be bathed with the same type of herb in order to foster brotherliness among them. Babies who were sick after birth, especially those caused by spiritual forces including *asram*, were given some of these herbs to bath, smear on their body or drink. Asram is a serious disease believed to be caused by spirits and can only be cured by TBAs or herbalists using herbal concoctions. More on asram is discussed later.

> "*If they come to tell me that the baby has asram, I treat them. I fetch some herbs for them to put in water to wash it in a new calabash. Then they bathe the baby from that calabash. Then the mother sprinkles a little of the concoction over the baby and a small portion for the baby to drink. Then the baby will defecate - he will defecate all the asram away and the baby will begin to gain weight. If she doesn't do that the baby will become very smallish and no matter what you do the baby will die. If it is that disease which has affected the baby- the baby will die*" (TBA B5 63).

Hospitals and clinics discouraged the use of these herbal treatments and sometimes staff rebuked mothers who were found to use them.

These herbal concoctions were prepared from various parts of the medicinal plant including the bark, leaves and roots (See Fig 7.7-8). TBAs fetched the plants by themselves or bought them on the market and some preparations required that the herbs were mixed with orthodox drugs.

Fig 7.6: A TBAs workplace (L1c) showing an enema bulb syringe, grounding stone for grinding herbs, and bottles and gallons for bottling concoctions for mothers.

Fig 7.7: A stem of a medicinal tree showing the bark cut to treat neonatal diseases.

In many Ghanaian homes, older family members, especially in-laws, have responsibility for caring for the newborn baby in the immediate post-natal period. It is also common for women to relocate to their parental home following delivery. They believe mothers, especially first-timers, lacked the necessary knowledge or skills to care for the newborn baby or mothers needed some time to recuperate. These older relatives often relied on their previous childcare or birth knowledge and experiences to care for newborn babies. Some of these practices, unfortunately, were ‘primitive’ (MD G22 15) and potentially harmful to the baby.

> *“They have a milk tin .... They make a hole under it and put hot water into it or warm water. And it is like they look at the neonate’s vagina and, if it’s a girl, the neonate’s vagina* [is considered] *as a sore, like a sore- in Dangbe they call it ‘pa- epe pa’, Ga’s say ‘fla’, Twi’s say ‘kuro’, you understand, Eve’s will say ‘abi’, you understand? So then she will part the labia and then will be dropping, or be titrating the hot water into the vagina, so there is no sterility, you know. Sometimes they use some herbs- I’m not condemning herbs, No that’s not what I’m saying but sometimes when they are prepared under domestic conditions, sterility becomes a challenge, you understand. So then the child picks up an infection at that tender age and the child begins to discharge* [pus]. *Within a short time septicaemia sets in, so they bring the child when the temperature is uncontrollable and there is nothing they can do. We try to do our best but within, sometimes within hours, the babies die- within hours not even days, within hours! There are those that the grandmothers would put some herbal- they grind bottle and add some mixtures to it and then apply it to the umbilicus and you know that is a quick way of infection transfer so it goes into the system. So majority of these children come with septicaemia, and they come and die”* (MD G22 15).

Other practices included mixed feeding in the early neonatal period because breastmilk was considered not satisfying, applying hot compresses to the head of the baby to mould it nicely, giving the baby water to drink to welcome him, bathing babies with cold water in order to clear the vernix from the body. Mothers who articulated their non-support for such practices, or indicated they were taught the contrary during ANC visits were reported to be age-bullied. These in-laws were said to remind new mothers that they gave birth and took care of them, or their husbands, and as a result know better. Sometimes these older relatives did these on the blind side of the mothers. Some clinicians also intimated similar challenges in educating older relatives on care of the newborns.

"It is difficult teaching people who think they know better. And they will tell when we gave birth to you, 'that is what we did and that is why you became a doctor'" (MD G22 15).

7.6.3 Cultural norms, misperceptions and costs of caesarean section promote home delivery (L1ab)

Maternity care providers in Kintampo and Dodowa reported a high social value associated with home delivery (In Navrongo, home deliveries have been banned for at least the past three years). Mothers who delivered at home were considered strong or experienced, priding themselves in their ability to endure labour pains, and those who delivered in hospitals were considered 'weak', needing assistance.

"They [women] *believe that being delivered in the hospital is a sign of weakness- that the woman is not strong enough to be delivered in the home"* (MWH Q4).

A short labour duration was also considered a sign of strength and mothers desired to spend a very short time at the labour ward. Women therefore spent longer hours at home and sought delivery service at an advanced stage, or took herbal preparations, popularly referred to as *'local oxytocin'* to hasten delivery. Midwives indicated that since there was no prescribed dosage for these preparations which takes into account mothers physical characteristics like age and weight, mothers often took an overdose of the concoctions which stimulated continuous contractions and did not allow the child any breathing space consequently leading to asphyxia (L4b). In hospitals or clinics, these concoctions were prohibited but TBAs prescribed them for mothers which made home deliveries more appealing.

Mothers who were delivered via caesarean section (CS) were described in even more derogatory terms like '*incomplete*', *'not real women'* or *'lazy'*. These mothers were said to feel '*ashamed not to have pushed out their own baby'* (TBA Q26). TBAs sometimes threatened to transfer mothers who were being uncooperative during a home delivery to the hospital and these women complied accordingly. It was believed that difficult or prolonged labour which warranted surgical interventions were consequences of infidelity, having children out of wedlock and misattribution of the paternity of the child. Caesarean section was therefore undesirable since it raised speculations and women preferred to be delivered at home, where there was no possibility of a surgical intervention.

> *'A woman who does CS means that she may have done something against the husband which she has not yet confessed'* (MWC Q40).

In religious societies, surgical intervention was considered an interference with the natural process and a sign that the '*gods are against you*' (MWH Q27), or a curse '*from the devil'* (MWH Q39). Pastors therefore prayed or prophesied that '*no blade will touch the woman during delivery'* (MD Q7). Some pastors also gave pregnant women in their congregation 'holy water' or 'holy oil' to avert any evil spells and help the woman through pregnancy safely. Women who were informed they needed surgery therefore called on their pastors or husbands who sometimes did not give consent for their wives to have surgery.

> *"The interesting thing is that yesterday, the patient did not necessarily understand the explanations we gave her, so she called her pastor and the pastor said that they wanted to take her away… Once she called the pastor and told the pastor her challenges, then the pastor called her husband and they came with some degree of impunity and arrogance, you know. 'We want you to transfer our patient; we are coming here for you to transfer our patient'. I realized that when the guy behaved, I mean, in his usual behavioural activity. I just asked him straightaway, you are a pastor, aren't you? Then he was shocked, how do you know? Then I said, Oh! It's pastors who behave like this. And the funny thing is that you won't get the pastors of the well-established ancient churches- like the Methodist church, the Presbyterian church, the Anglican church, the Catholic church, you know, you won't get their pastors doing this. It is always these international churches- like something international, something finger international, something miracle centre international... God power house international, these international* [churches]. *Pastors from these international churches are always those doing this kind of thing and it is a big challenge"* (MD G22 15).

There were perceptions that once a woman undergoes an operation, she would never be as strong as before or caesarean section would restrict the number of children a woman could have and once you are delivered via caesarean section, all subsequent deliveries will be via caesarean section. Since most women were engaged in labour intensive occupations, for example farming, and large family sizes were desired by many rural women, caesarean section or hospital delivery was not appealing. Even mothers who had obstetric conditions like fibroids refused to deliver in the hospital because they perceived doctors could perform tubal ligation during a caesarean section.

> *"If you remain steadfast and continue to give birth, in the long run you will get some of the babies. Because of that the women endure and patiently try to get pregnant and they are able to have 5 to 6 children. Even if 3 of them die, there will be 2 more of them alive. I know a woman in this village who has been operated upon, the womb also came out and she couldn't deliver again"* (TBA B9 70).

Midwives also revealed that women were simply '*scared of the idea of surgery*' (MWH Q45) because a safe outcome was not guaranteed. Some women believed that there was a possibility of '*an overdose of the anaesthesia and not wake up again*' (MWH Q56). These fears were high especially among women who were reported to have heard of or known someone who died during a caesarean section. But a midwife explained that women who had caesarean section became more conscious of their health and were likely to attribute anything that happened to them following the surgery to the caesarean section. Other reasons for refusing caesarean section were economic. Costs for having a caesarean section could be about GHC 300.00 (£52.00), including costs for drugs used, compared to GHC 50.00 (£8.70) for vaginal delivery. In addition, surgical wounds took longer to heal and thus would require longer periods of hospitalisation which would increase the cost, and the opportunity cost of lost time to go to farm or other income generating activities.

> *"Some have no support after the CS so they would not like it- because they need to return to their normal work after CS"* (MWC 19).

In hospitals and clinics, all women were required to assume a lithotomy position during delivery but in the homes TBAs allowed women to squat, if they wished to. Women believed that lying on the back to deliver prolonged the labour duration and so they preferred to be delivered at home.

7.6.4 Mothers' obstetric decisions are influenced by relatives, spouses and religious leaders (L1a) and costs of services (L1b)

Many women consulted their husbands, older family relations and religious leaders concerning key obstetric decisions. In most Ghanaian homes, men remain the breadwinners and figureheads with responsibility for making key family decisions. This is more so when the wife is heavily pregnant and cannot work. Women therefore depended on their husbands for resources to seek maternity care. Sometimes the husbands could not afford obstetric services or were not willing to spend and so advised their wives to seek less expensive traditional sources. In other compounds, decisions about where women sought care were determined by older relatives, more often women's parents or in-laws, and some of them delivered their own daughters at home.

> *"And some too we tell them to go for a scan whenever they are pregnant so that we can know where the child lies- whether the child is lying well or not. Some of them will refuse to go. They exclaim, 'my husband does not have any money! My husband that…'"* (TBA B6 59).

There were a few instances where women refused to follow the advice of their husbands. For examples where a woman had some savings to attend a hospital or clinic or where the husband advised the wife to attend a hospital but the wife preferred to be delivered by a TBA.

Delivery service in Ghana is supposed to be free, at least de jure, but de facto there are several indirect costs, including transportation fees and a long list of items women are expected to purchase for clinic or hospital delivery (described in detail in Chapter 6.3.4). It was reported that many women found these costs extortionate, and some husbands were reported to consider their wives who wanted to deliver in a health facility as being insensitive to the family's economic plight. Meanwhile, TBAs did not demand any such items or charged relatively little money or accepted non-monetary gifts including crops from the woman's farm.

> "*Some women come here empty handed but they cannot go to the hospitals empty handed. We even feed them here*" (TBA B7 71)

Among women who made it to hospital, it was reported that some sought permission from their husbands or pastors when presented with a reason to consider caesarean section, even in emergency situations. Many women believed that the outcome of pregnancy was influenced by spiritual forces and so they sought spiritual direction from their pastors, who in turn consulted the woman's husband. When the pastor's advice contradicted what clinicians advised, mothers heeded the counsel of their pastor or husband.

> *"In fact this gentleman I was talking of, the wife told us, when I told her, look, your case is an emergency and we have got to go to the theatre and take the baby out so that you will have yourself and have your child. She said No, she needed to consult the husband. When the husband came he refused. So she wrote in her folder 'I WILL NOT HAVE THE SURGERY DONE BECAUSE MY HUSBAND SAYS NO', and she signed. When I looked at this I was worried. I was critically worried because I thought I was dealing with two ignorant citizens of the Republic of Ghana"* (MD G22 15) [The doctor proceeded to a nearby court to secure an order to operate on the woman, and the baby survived].

Spousal or pastoral interferences with clinical care were common, especially in southern Ghana, and sometimes, doctors resorted to the courts for legal authority to go ahead and perform lifesaving surgeries.

> *"I just drove to the court at the top there to go and see if the judge, the sitting judge, could give some backing and power to go ahead and save the bleeding woman. I regarded this as violence against the woman because if you are the husband and your wife is bleeding to death and you are saying that No* [she can't have surgery to save her life and that of her baby], *then it means that is violence ... I mean its violence because*

> *she is going to die and if you hit her head with a chair too she will die. So it's all death, like somebody said that 'all die be die'* (MD G22 15).

Cultural and religious beliefs about surgical interventions are discussed in the next section. It was suggested that wives required their husband's approval to make important clinical decisions, not because of their knowledge or experience but because of the societal structure. This is indicative of masculine dominance especially since husbands were unlikely to consult their wives regarding their health.

7.7 Individual and family factors influencing place of delivery (Level 2)

7.7.1 Maternity services are readily available in urban centres than villages (L2c)

The interviews showed significant differences in the availability and accessibility of skilled maternity services between mothers who lived in rural areas and those who lived in urban areas. Women who lived in towns (urban) had easy access to a hospital or health centre with doctors, physician assistants and midwives and relatively advanced facilities, but in villages the nearest health facility was a CHPS clinic which was managed by either a midwife or a community health nurse with very basic equipment. Most CHPS clinics, with the exception of Navrongo, were managed by personnel who did not have skills to conduct delivery. Women who lived in these villages therefore had to travel longer distances to access skilled maternity services, but access could be complicated by difficulty in obtaining transport means.

> *"So I asked the mother of the pregnant woman to go into the village and check on getting a car but she couldn't find any. So I asked the pregnant woman if she could sit on a motorbike, but she said No. If she could sit on the motor I would have taken her* [to the hospital]. *But she said No*" (TBA B6 59).

In these villages, vehicles were usually available on specific days of the week, for example on market days. Although midwives in the clinics and TBAs said they took down the telephone numbers of some taxi drivers to call on in emergencies, they were not always available and some drivers refused to transport a patient late in the evening because the roads were unsafe. The national ambulance service was also reported to be unreliable.

> *"So we ordered and they gave us the ambulance* [telephone numbers] *so the ambulance is there. But even the facilities are not coming how can you call the ambulance driver at Dodowa to wake up from his home to come to the ambulance service, come here and take you. By that time what will happen would have happened"* (MWC G25 Q44).

Sometimes women were turned back home after making such hard journey to reach health facilities because labour had not really set in or contractions were false, and midwives indicated that women rarely returned to deliver with them. CHPS clinics in the villages did not have capacity to admit patients so patients often had to go home and return later.

> *"In fact for her, she had been in the clinic earlier and we told her that her time was not due, so if she could get someone to stay with in this town, she should stay with the person, so that when her time is due she would come* [to the clinic]. *When she left for the house, I didn't hear from her again. Then she said she doesn't have any relatives in this town so she walked back to the village she came from. So she delivered late in the night and they couldn't deliver her placenta"* (TBA B6 Q59).

There were also reported cases, especially in the clinics, where no maternity care provider was available. Many CHPS facilities did not operate for 24 hours and the midwives in-charge left for their homes in nearby towns at the end of the day or left to visit their families in the city during the weekend, with no provision for cover. TBAs on the other hand often lived in the communities in which they served and thus were more reliable.

> *"I saw the pregnant woman come to the clinic and then return home until about the third time when I didn't see her come back to the clinic again. I didn't know whether she was in labour and it is not a policy also to approach anyone you see* [coming to the clinic] *whether they were in labour or what is wrong with them"* (TBA B6 59).

The interviews also found that skilled birth providers in hospitals and clinics provided institution-based services only. Doctors and midwives always waited in their facilities to attend to women. It was common for clinicians, therefore, to say things like "*when the woman came*" or "*we were here when she reported*". Midwives and doctors therefore blamed women for not seeking maternity care on time. In contrast, TBAs provided mobile services and were always available on call. TBAs usually said "*and once they called me, I picked my box and I left*" (TBA B11 69), or "*the husband came to pick me*". TBAs delivered mothers wherever convenient - at the TBAs facility, the mother's home, or even in the street if labour was so advanced that mothers could not be taken to a health facility.

> *"Yes, it's a far place…. He* [husband to the woman in labour] *came to pick me with a cycle* [bicycle]. *So by the time I went the buttocks* [of the baby] *had come out. In fact when it happened that way I panicked a little… I panicked because I have never delivered anyone who was presenting with the buttocks. But this one was presenting with the buttocks, I asked how would I deliver the mother, but I reassured myself that God is king- in the same way I delivered the one that presented with the face it will be the same way I will deliver this one"* (TBA B7 71) [The baby survived].

In essence TBAs, and therefore home deliveries, were readily available, accessible and more reliable than skilled maternity services, especially in situations where transporting women to a health facility was not possible or in villages where access to transport was restricted. The mobility of TBAs also reduced, even removed, the costs of transporting women to health facilities. The lack of transportation in the villages also meant that babies who were born sick could not have access to a health facility on time which could increase their risk of death.

7.7.2 Trust and rapport have a role in mothers preferences for where they deliver (L2d)

Mothers were reported to be more comfortable when delivered by personnel who shared their beliefs or in settings which allowed them to express their culture. TBAs appeared culturally aware and often allowed women to express their beliefs, but hospitals and clinics often had laid down procedures which were unreceptive to religious or cultural beliefs and expressions.

> "*There are some practices we wouldn't allow in the hospital so mothers may not want to come to the hospital*" (MD Q48).

For example;

> "*Some* [cultures] *believe that the placenta needs to be buried in the bathroom so that they prefer to be delivered in the house so that they could bury their own placenta rather than the hospital where they wouldn't get their placenta*" (TBA Q60).

In hospitals, all placentas were discarded in a bigger placenta bowl and so it was difficult to trace which one is for the mother. Unfortunately, many women could not speak out because they were 'scared' of midwives.

Some midwives were also reported to shout at the patients during labour because they were '*uncooperative*' (MWH Q40). Women of less social standing, including poor, less educated or women from rural areas, were said to be made to '*feel inferior'* (MD Q54) because midwives could be *'rude and unfriendly'* (TBA Q69). One midwife explained that sometimes she yelled at women in labour because they refused to bear down even though the baby's head was in vaginum and further delay could asphyxiate the baby. On the other hand TBAs said they "pampered" the women. They mashed kenkey with milk or bought a malt drink for mothers who came in labour without haven eaten any food. Kenkey is a staple made from corn and it is considered high energy producing; serving kenkey with milk or buying a malt drink for someone was considered a treat.

> "*Some* [women] *simply don't want to be frustrated or shouted upon – but in the facilities the midwives shout at them*" (TBA Q66).

TBAs were usually older women with many years of practice experience and have lived together in the communities with the mothers and so were considered a part of them. Women therefore '*trusted the TBAs because they lived with* *them in the same community'* (MWH Q45) and '*they felt they know them* [TBAs]' (MWC Q31). The confidence of mothers in TBAs soared higher if the TBA had been involved in conducting deliveries for a longer time and in some communities, it was almost customary to deliver at home.

> *"As for we Dagombas and Kokombas we give birth at home because we have many people who conduct deliveries"* (TBA Q72).

On the other hand, midwives in hospital or clinic were generally younger and of a different cultural background from the community they served because they had been transferred from another community or region by the Ghana Health Service following completion of midwifery training. Some mothers thought they were *'too young to be conducting deliveries'* (MWH Q45).

Secrecy during pregnancy is encouraged by many Ghanaian cultures because pregnancy is considered a very vulnerable period, and mothers prefer not to announce their labour. There are also some mothers who do not like to be delivered by people they didn't know for various cultural reasons. The Fulanis, Kokombas and some Muslim communities, for example, did not like to expose their perineum to '*strangers*' (MWH Q12) and in the Akan culture, it is believed that every child comes into the world with a special destiny and '*a bad person conducting delivery could exchange the child's destiny*' (TBA Q70). Some mothers also feared that babies delivered in the hospital or clinic could contract 'asram' when someone, a bad midwife or another patient on the delivery ward, with an 'evil eye' transmits it to the baby due to the dormitory nature of maternity wards.

> *"Some TBAs threatened the mothers that if they went elsewhere to be delivered and the babies get asram, they would not treat and so some go to the TBAs for fear of asram"* (MD Q49).

Mothers therefore preferred to be delivered at home by a single TBA or with an assistant, rather than in the hospital, where they were attended to by a team of health personnel.

7.8 Place of delivery and neonatal complications

7.8.1 Treatment of neonatal conditions depends on beliefs about cause of illness (L3abc/L2d)

There was a general understanding among care providers that sick babies needed professional care, but the type of care babies received depended largely on what mothers believed to be the cause of neonatal illness. Mothers, especially new mothers, were said to often seek advice from older relatives or community members regarding treatment for illnesses of the newborn. If mothers believed the neonatal disease to be caused by spirits, they sought treatment from a TBA or traditional healer, but if they believed the disease was of a physical origin, they went to the clinic or hospital.

> *"Even if the mother doesn't know it is asram* [a type of spiritual disease]*, someone will see it and direct the mother to my place* [TBA]. *The person will notice what is on the baby and then immediately she will bring the child"* (TBA B9 70).

The most common spiritual neonatal disease was *asram* and TBAs said it was the main cause of neonatal deaths. Although asram is an Akan word, beliefs about asram were common in all three research sites, especially in the Kintampo area, and Akan traders from the central and southern Ghana travelled up north to sell the herbs for curing asram. It was believed that midwives or doctors in hospital had knowledge of only physical conditions but TBAs had insights to treat both physical and spiritual diseases.

Asram was described as a neonatal condition caused by evil spirits and is transferred from a bad person (host) to the baby in utero, at birth or within the first week after birth '*when the cord has not fallen off*' (TBA Q51). The host was believed to transmit the asram spirit by simply looking at the baby with a '*bad eye*'. Pregnant women who disregarded cultural values of eating in their homes or modest dressing during pregnancy were said to make their babies vulnerable to asram, although it could be transferred by the malice of evil people. It is characterised by many nonspecific signs including distended abdominal veins, albumin looking patchy faeces, frequent crying, inability to breastfeed and dehydration among others but *'once you see the veins become black, then you will know it is asram'* (TBA B9 70). Asram was said to be fatal if the appropriate herbal treatment was not started on time.

Most midwives and doctors in hospitals and clinic said they had heard of asram but were divided about what it was. Some doctors believed asram was a general term used referring to any neonatal sepsis or neonatal illnesses.

> "*Asram- failure to thrive- any condition that hampers or retards the growth of the child – that is called asram. It is thus a generalised term for AIDS or TB…*" (MD Q48)

Others said asram referred to malnutrition, neonatal tetanus, meningitis and impetigo. There were some midwives who doubted its existence saying '*there is nothing like asram- it is a mirage of diseases*' (MWH Q52). TBAs, however, were confident asram was a unique disease and three types of asram were described: '*asram bodeba'*, '*asram asiwumu'* and the main '*asram*'.

7.8.2 Assessment of labour and management of high risk delivery among maternity care providers (L3abcd)

Doctors and midwives were knowledgeable about standard assessment techniques and some hospitals had sophisticated equipment to monitor fetal wellbeing in utero. For example midwives estimated the gestation age of the fetus from the early booking scan of the mothers, or by checking the symphysiofundal height. In hospital and clinic, assessments included palpations, auscultations, vaginal examination, checking of vital signs and observations, and midwives followed standard documentation procedures.

> "*You check their weight, you check their BP, then you send them to the delivery room and you do a head to toe examination and you check the SFH* [symphysiofundal height]. *After checking the SFH then you do palpation to check the lie of the baby, you listen to the fetal heart, then you do the VE* [vaginal examination] *to check the condition of the vagina - the dilation, the membranes. Even with the vaginal examination you can even know the position- if it is head- the cephalic.* […]. *You will do all*

these on the mother and it is routine. And if the membranes are ruptured you check the liquor - the smell and other things" (MWC G25 Q44).

"*Before delivery if she is ready for partograph you place her on a partograph. You monitor her. So on the partograph we have all the monitoring- the fetal heart, the VE, the descent, temperature, BP all that till she delivers*" (MWC G20 Q7).

Proper assessment techniques by midwives in clinics and hospitals therefore made it easier to identify high-risk deliveries and make appropriate referrals on time. In contrast, most TBAs used very rudimentary equipment to deliver mothers in their homes and they were not knowledgeable about standard measurements. The majority of TBAs did not wear protective clothing or gloves during delivery, which put them and mothers at risk of infection transfer.

"*Some people when they have high BP I cannot tell, but from how their eyes would appear or how warm they would be then I would go and buy them a malt drink to take*" (TBA G24 Q45).

Some TBAs said that they knew they were not to deliver very young mothers, first time mothers, mothers with pre-existing medical conditions or other high risk deliveries, but sometimes the women begged them for help because they did not want to go to the hospital or they could not afford to.

"But because of the difficulty with money if you asked some women to take their babies to the hospital they wouldn't go… You will ask them to go to the hospital but the mother will keep insisting that they would want to be delivered [by the TBA] *because they don't have a dime. This will make the baby weak in the womb and by the time the baby is born he wouldn't be strong. Then you will know the baby is not healthy because of poverty*" (TBA B9 70).

7.9 Direct causes of neonatal deaths (L4abcd)

7.9.1 Management of prematurity: hospitals have capacity to manage premature babies but clinics and TBAs do not (L4a)

Maternity care providers were aware it was possible for a baby to be born before nine completed months of pregnancy but their management differed significantly between delivery settings in Ghana. Hospitals had most of the equipment and drugs needed to manage preterm babies and some had neonatal intensive care units (NICU) or had improvised one to manage very preterm babies. The management priorities for preterm labour in hospitals were to keep the baby in utero - *'the best incubator'* (G22 15) - by encouraging bedrest for the woman in preterm labour and administering appropriate medication, usually magnesium sulphate, to stop the contractions, and steroids, usually dexamethasone, to mature the lungs at least 24 hours before delivery.

> *"She* [the mother] *came here with losing liquor so she was given injection dexamethasone and we admitted for bed rest and save pad* [to measure the liquor she was losing]. *She was scanned by the doctor and the baby was viable. She delivered, the baby was active but preterm. But we sent the baby to the NICU"* (MWH B1 57).

But some doctors in hospitals said they did not have all the drugs needed to help preterm babies, especially those who had difficulty breathing.

> *"We think it might have just been this Respiratory Distress Syndrome, we are not too sure of that it will happen. Even though most of those ones, the only thing we have available here is usually Aminophylline. We start Aminophylline to help them but it doesn't do as much. If you are thinking Respiratory Distress in the new born most of them do better with the surfactant replacement rather than just giving Aminophylline and those things but that is the other side of the handicap"* (MD N6 6).

Midwives in clinics said they did not have the drugs or facilities necessary to manage preterm births therefore they transferred mothers who presented with premature labour to the hospital. However, if mothers came in at an advanced stage of labour, then they had to deliver the baby. In clinics, mothers were encouraged to use appropriate clothing or the Kangaroo Mother Care technique to maintain warmth. Midwives in clinics said they transferred inactive preterm babies, those with very low birth weight or difficulty breathing to the hospital, but active ones were managed in the clinics. Before the discharge to the house or transfer to hospital, midwives in clinics said they educated the mothers regarding the management of the preterm babies.

> *"The mother was there so I also told the mother that that baby was a special baby and it's not everybody that can take the baby like that and if anyone wants to help you also need to wash your hands before. So after educating them and arranging for the means, I now did the kangaroo mother care for the baby and then I took them to the hospital"* (MWC N8 Q18).

Some TBAs said they transferred women who experienced preterm labour to the hospital but most said they simply delivered preterm babies because they believed it was God's will for some babies to be delivered before 9 months of gestation. Most of the preterm births reported by TBAs were spontaneous and not anticipated. According to some TBAs, delivery of preterm babies was even much "*easier than term babies because preterm babies were smaller*" (TBA B9 Q59). The only exception to preterm delivery, according to TBAs, was if the gestation was eight months old. TBAs believed it was possible to deliver a seven month pregnancy but an eight month old preterm could barely survive.

> *"An 8 months baby cannot be delivered; he will not survive because he would have changed to blood again. As for the 7 months old baby I am able to give her some drugs for her to deliver"* (TBA G24 45).

To manage preterm deliveries, some TBAs prepared herbal concoctions for the mother.

> *"I gave her some of the concoctions I boil in order for the baby to stay a bit longer in the womb. I noticed that the baby wanted to come before its time but because the baby was still coming she gave birth to him. So when I noticed the baby was coming, nonetheless, I changed the concoction to the one which is given to a woman in labour and she delivered*" (TBA G24 45).

Most TBAs said they transferred a preterm baby to the hospital for further management but some maintained that they would not refer a preterm baby to the hospital if the baby was active. TBAs said they maintained warmth by limiting exposure of the newborn and encouraged the mothers to cover the newborn with adequate clothing but some treated the preterm baby, especially the active ones, as they would a term baby including bathing the preterm with cold water after birth. Others said they were not aware preterm babies needed special care in the hospital.

> "*I cleaned the baby although the baby was small. I didn't know they put the babies in a glass* [incubator] *that's why I didn't ask her to take the baby to the doctor. It was later I got to know that is how they care for sick babies*" (TBA B10 68).

There was some indication that TBAs trusted the medical expertise of doctors and midwives. Some TBAs reported that they learned how to better care for preterm babies, for example not to bath preterm babies, after they took a previous preterm birth to the hospital. The doctors and midwives also encouraged TBAs to transfer all the babies they delivered to the clinic or hospital for immunisation.

7.9.2 Management of neonatal infections: hospitals lack of specialists, CHPS do not have medications for sick babies, but TBAs have concoctions (L4c)

It was reported that mothers sought treatment for newborn illnesses from health facilities, unless they believed that the disease was *asram* or of other spiritual origin. The commonest infection reported by midwives and doctors in hospitals was umbilical cord infection. Midwives and doctors said that cord infections were common because caregivers of newborn babies applied herbal concoctions and other substances to the cord which led to infections. Birth practices among caregivers in Ghana have been discussed in the previous section.

> "*The cord was offensive; they had applied all sorts of things so we cleaned it off with spirit. They applied toothpaste, at times ash and then salt. You know the baby got an infection through the cord so we cleaned it up then started antibiotics… The temperature was about 39 degrees*" (MD G21 26).

Doctors and midwives in hospitals and health centres said they managed all types of neonatal infections using appropriate antibiotics, but diagnoses of neonatal infections were symptomatic and rarely based on laboratory results.

> *"We kept the baby here, after some few minutes we gave the baby antibiotics - admitted the baby for IV antibiotics. Yeah, we were thinking that the baby would have gotten some infections - because later on the temperature was high- we thought that may be there was some aspiration or something like that"* (MD N10 19).

In Ghana, health centres do not have a doctor but a physician assistant, and all the hospitals included in this study were district hospitals which did not have a paediatrician. Babies were therefore cared for by general doctors or doctors of other specialties. In health centres, complicated cases of neonatal infections were transferred to the nearest hospital but in hospitals, doctors were often in a dilemma as to what to do. Transferring babies to tertiary facilities was not always convenient because doctors feared the state of the road or ambulance might be detrimental to the baby.

> *"There is always the dilemma of whether to transfer the baby to Techiman* [the regional hospital] *or keeping them here, and then the challenge of how to keep the baby in an ideal position till you get there and whether it will make a whole lot difference if you send the baby to Techiman. The baby is ill, you do not have enough oxygen to support the baby on the way. You don't know how the baby will take the stress of the shaking and all of the movement. Even in your attempt to move the baby you may lose the baby because you cannot keep the baby warm enough and cold could kill the baby. It is a tough decision to decide whether to move the baby at all"* (MDH B2 53).

There were also reported cases where the tertiary hospitals refused to accept admissions from district hospital because they did not have enough bed space and one doctor said he had stopped transferring sick children.

> *"Because there are no beds. So practically, we have stopped referrals from this hospital. Practically, concerning maternal* [and neonatal] *health I mean"* (MD G22 15).

Some doctors phoned the specialists in the tertiary facilities for advice.

> "*Sometimes you are at your wits end and you wish there was a specialist around who could help you. Sometimes we talk to the paediatrician* [over the phone]. *We talk about it and we leave it like that. He says okay you are doing this, aren't you? You are checking that, aren't you? You are giving the oxygen, you are giving the glucose. Continue the monitoring. Make sure that this and this and that do not happen. If the seizures do not stop do this. But it's still difficult*" (MDH B2 53).

Fig 7.8: Example of a plant, *Heliotropium indicum* (locally known as akokotubetube) for treating neonatal infection.

Midwives in CHPS compounds said they did not treat any neonatal conditions because they did not have the medications for babies or if they prescribed drugs, mothers would have to pay for treatment. Therefore they referred sick babies to the nearest health centre but their mothers rarely followed through to the hospitals. These women conveniently went to the nearest TBA or simply asked other women for treatment for their child's illness. Some TBAs felt neonates were too small to be treated with herbs, except for asram, and so they transferred babies to the nearest health centre or CHPS compound but others felt the need to help, nonetheless.

> "*If the baby is born and he has the disease you will be the same person to help him. If you have any medications to help him, then you will have to help them*" (TBA B9 70).

7.9.3 Management of birth asphyxia: Hospitals and clinics used resuscitation techniques and TBAs used varied crude techniques (L4b)

Birth asphyxia was the most commonly reported adverse birth outcome among maternity care providers. According to midwives, almost all the cases of asphyxia were due to prolonged labour (more than 30 minutes in second stage of labour) because mothers did not report to clinics or hospital on time, or were not willing to push in the second stage of labour or had used some concoctions (local oxytocin).

> "*The concoction it is having effect on the mother. The contractions become strong and frequent so there is no breathe* [space] *for the baby*" (MWH B1 57).

According to TBAs, poor maternal efforts were likely because some mothers do not eat when in labour or mothers may have started pushing at an early stage so they were exhausted by the second stage. TBAs therefore gave these mothers food to eat. In the clinic and hospital, women were supported with intravenous infusions. Some women were said not to bear down because of the labour pains, but they were rarely given pain relief medications because of unavailability.

> "*The pain is too much- which is always a common feature for most of them because most of them don't get pain relief- almost all. First because of availability- it's not available and so we don't give at all*" (MD N6 6).

In some cultures, for example in Navrongo, health professionals did not give pain medications to parturient women because they believed that labour pains must be endured. Others did not give pain medications to women in labour because they believed that the pain medications were associated with poorer outcomes in the babies.

> *"May be, myths- people kind of believe labour is painful so you have to feel the pain so people are not just interested in taking pain killers. I'm sure the health workers just don't want to offer it because they know that labour is painful. Some think that most of the pain reliefs that we give when you deliver the baby, the baby might have unfavourable scores because you can sedate the baby if you give those ones may be- morphine, pethidine- those are the usual ones they may want to give. Those ones may have a sedative effect on the baby when the baby is delivered. And so they are not too sure is the baby just asphyxiated or is it because of the pain reliefs"* (MD N6 6).

Regarding the management of birth asphyxia, all hospital and clinic staff indicated that they positioned the asphyxiated baby on a resuscitation table, suctioned the nostrils and mouth of the baby with a bulb syringe to clear the airway and then resuscitated the baby using the ambu bag. In hospitals and health centres, severely asphyxiated babies were given oxygen and appropriate intravenous infusions.

> *"So quickly I had to suction the mouth, the nose and stimulate my baby but still* [she was unresponsive]. *So we quickly cut the cord and took the baby to the resuscitaire and start positioning the head.* [...]. *You make sure that there are no fluids, no liquor in the airway because if there is and you are inflating, you are even suffocating the baby. So you clear the airway- mouth before the nose- I did and position the head and give your bag and mask, ambu bag, breathe-two-three, breathe. Then everything* [APGAR] *was rechecked, repositioned and low and behold, later our baby, we had the baby's* [breathe] *started coming"* (MWC B4 65).

TBAs did not have the necessary equipment to manage asphyxiated babies and the treatment of birth asphyxia varied depending on her or his education or source of training. TBAs who were more educated or those who received primary training from a health professional attempted to clear the airway with a towel or cotton wool, or a bulb syringe and then did a mouth-to-nose resuscitation using improvised devices. Doing a mouth-to-nose resuscitation for the baby however was not very efficient as TBAs got tired after a few rounds.

> *"You know it is a lot of work* [to resuscitate a baby]. *It is my breath that I have to give to the child. I get tired breathing for the child and then I stop and sometimes as I pump* [with the bulb syringe] *to the point that my arms go numb"* (TBA B6 59).

TBAs who learned how to deliver from their relatives or other sources employed primitive measures they learned from their older parents.

> *"So as the baby came out he was weak as if he was already dead. But I had seen how my elders treat such babies so I also adopted the plan"* (TBA B11 69).

These methods usually involved crude measures aimed at stimulating the baby to wake up. For example putting a wet towel on the baby's face, pouring water on the asphyxiated baby to revive him, giving the baby lime juice to drink or drumming into his ears to wake him up, or warming the placenta in warm water with the baby attached on the other end, or giving the baby an enema.

> *"If you deliver the baby and he comes out and he is not responsive, that is when we pour water over him ... over the child until he sneezes before we leave him. But if he doesn't sneeze, we pick the jarrican* [a plastic gallon] *and we drum it… we drum it for a while into his ear until he screams.* […] *We will drum for some time* [about 1 hour] *and* [if] *the child will not get up, but we will also not stop.* […]. *So if you do that and it is because of the tiredness, the water will make the child to shiver. […]. Because as you pour the water on him, air also passes around him and the air currents will make him feel cold then he will scream"* (TBA B11 69).

Most maternity care providers, including doctors, midwives and TBAS, indicated that the part of management they often struggled with was resuscitating an asphyxiated baby.

> *"But just getting her to breathe properly- getting the baby to breathe properly. That was the most* [challenging thing]. *Because at times you could see that the baby was making some efforts but it was difficult so I*

think the most challenging part was getting him to breathe properly" (MD N6 6).

When asked how if they would manage a similar case of neonatal asphyxia differently in the future, some TBAs indicated that they would not change anything but most agreed that they would send the baby to the hospital.

> *"If I am to meet something similar and the condition has not reached the current one I experienced, I will find a car and join them and take them to the hospital because that is where there are better machines but in the current case where it was remaining with only the head, if I had asked that we put the woman in a car (to the clinic) it wouldn't be helpful"* (TBA B6 59).

7.10 Discussion

Quantitative studies are helpful in determining the rates, causes and risk factors- the Whats- of neonatal mortality and estimating the sizes of those effects (5, 27, 266). They fail, however, to explain the reasons and context underlying those neonatal deaths- the Whys. The overall aim of the in-depth interviews was to provide a practical understanding of the context underpinning neonatal mortality in Ghana. Mosley and Chen's (1) model for child mortality was adapted as the analytical framework for exploring the data on neonatal mortality in Ghana (Fig 7.5). The results showed that neonatal mortality in Ghana was largely influenced by where mothers sought maternity services (Level 3), i.e. where babies were delivered or where sick babies were managed. Mothers' choice of place of delivery or place for seeking care for newborn illness were in turn influenced by societal factors (Level 1) including socio-cultural (L1a) and economic factors (L1b) and mothers' level of autonomy (L1a) and individual and family factors (Level 2) including access to maternity services (L2c), beliefs about origins of disease (L2d), and attitudes towards maternity care providers (L2d). Since different delivery settings in Ghana have different types of maternity care providers (Level 3), this implies that neonatal mortality was influenced by the type of personnel who delivered babies or managed sick babies. Babies delivered or managed by skilled personnel, in hospitals (L3a) or clinics (L3b), received better treatment but those managed by TBAs at home

(L3c) were cared for using traditional approaches which were potentially harmful and increased risk of neonatal death.

7.10.1 Cultural and birth practices and belief patterns among maternity care providers

The WHO has developed a set of evidence-based guidelines to help maternity care providers acquire the skills and knowledge to provide appropriate care for mothers and newborns during pregnancy, delivery and postpartum (251). The essential newborn care component include recommendations for clean delivery and cord care, thermal protection, early initiation of breastfeeding and exclusive breastfeeding, resuscitation, eye care, immunisation and care for neonatal illnesses. Although these guidelines are considered ideal to ensure highest survival for newborns, their adherence will depend on their congruence with local birth practices or beliefs, and acceptability among maternity care givers. It is imperative, therefore, to understand existing birth practices to design appropriate behavioural or educational programmes to change harmful practices at the community level.

According to Mosley and Chen (1), the primary variables which influence mortality in children are socioeconomic, and these operate through proximate factors (biologic) to produce mortality. The authors identified three levels of these socioeconomic determinants: individual, household and community. This study found culture and belief patterns are as important community (Level 1) and family level factors (L2d) which influenced where mothers sought maternity services. Doctors and midwives (L3ab) believed that childbirth was natural and birth complications could be understood using scientific knowledge. TBAs believed that childbirth was controlled by supernatural forces, and pregnancy outcomes were explained by sociocultural beliefs- according to the will of the gods, the child's destiny or because a mother may have committed a sin (L1a). Previous studies have reported that TBAs believed some children were spirits who have come to worry their mothers and it was only the good ones who will be welcomed (370, 371). This fundamental difference in childbearing beliefs was evident in maternity care providers' approach towards caring for newborns and managing birth complications.

The differences in belief patterns or understanding of obstetric complications may be explained by the differences between care providers in the level of education (L1bd) and source of maternity training (L3abc). Most TBAs in this study had little or no formal education and were trained by their relatives who may not have had any education themselves. On the other hand, midwives and doctors received formal education and training in the science of human reproduction. It is possible for a scientific understanding of childbearing to override or mitigate cultural perceptions. For example, it has been shown in other parts of Ghana that TBA training programmes were associated with increased knowledge and scientific understanding and improved maternal outcomes (95). It was expected that the differences in childbearing perspectives could complicate communication and collaboration between TBAs and midwives, but this study showed the contrary. TBAs advised mothers to take babies who were delivered at home to hospitals for immunisation, and some TBAs said they adopted better care practices, for example not bathing preterm babies, after they were taught by doctors or midwives. This is a very important finding and it shows the potential for TBAs to lead public health education to dispel some of the cultural beliefs (372-375). More on care practices and management of neonatal complications is in the next section.

It was very encouraging to observe that almost all maternity care providers in Ghana initiated breastfeeding soon after delivery. This is a testament that education about the importance of early initiation of breastfeeding has gone down well. A study in Ethiopia has noted that the most common advice given during antenatal care was regarding breastfeeding (155). Edmond et al., (158) showed that initiating breastfeeding within one hour post-delivery is associated with significant reduction in neonatal mortality due to infection. Unfortunately, information regarding exclusive breastfeeding does not seem well adhered to as mixed feeding habits were common at home. Mothers complemented breastfeeding with soft gruels and porridges because they believed breastmilk was not satisfying enough and others gave babies water to drink as a way of welcoming babies. These practices are in conflict with the WHO guidelines for Essential Newborn Care described above (251), but are regrettably common in other African countries (79, 376). This study showed that mixed feeding habits sometimes led to asphyxiation and subsequent death of newborns. It was not possible to determine the extent of exclusive breastfeeding practices since this study was restricted to practices within one month, but with mixed feeding habits reported within one month of birth, exclusive breastfeeding becomes a mirage. It is advised that breastfeeding education during antenatal should emphasise the components of breastmilk and importance of exclusive breastfeeding.

There appears to be a policy-practice gap between the WHO guidelines for clean cord, thermal care, and eye care especially among babies born at home. Maternity care providers in hospitals and clinics were reported to adhere to clean cord and thermal practices and babies were bathed not less than 6 hours after delivery (251). At home, common cultural practices reported included traditional care of the umbilical cord, genitals, and fontanelles and bathing babies soon after delivery. Bathing babies soon after delivery is a major risk for hypothermia, even in high temperate countries (160-162). Newborn caregivers at home dressed the umbilical cord stump with herbs or other substances including ash and toothpaste to make it heal fast, or dressed the genitals of babies using hot water infused with herbs in order to heal any possible wounds or massage the head of the baby with hot water in order to mould it nicely and aid early closure of the fontanelles. Dropping hot water on the baby's genitals erodes natural defence mechanisms, and the unhygienic conditions under which herbs are prepared make babies susceptible to infections (377-379). Neonatal infection is one of the leading causes of neonatal deaths worldwide (5, 266) and a previous study in Ghana identified excess mortality due to infections at home (59). The practice of head moulding is common among almost all races, but its benefits or otherwise are unclear (380). To improve neonatal health in Ghana, newborn care recommendations should be an integral part of current maternal and child health policies at both facility and community level.

The use of herbal concoctions during pregnancy or labour represents a significant part of the healthcare in Africa (79, 381, 382). Traditional medicines are easy to obtain, affordable, culturally acceptable and perceived to be safer and natural compared to corresponding synthetic orthodox medications (383, 384). The sale of traditional herbs is an important part of the local economy (385). It is estimated that approximately 10- 15% of pregnant women in Ghana use some form of herbal medicine (386, 387). This is likely to be an underestimate as most respondents were questioned in formal healthcare settings excluding those at home. Despite the fact that a significant proportion of women use herbal medicines, many healthcare providers in Ghana have inadequate knowledge about its usage and the activities of most traditional healers are unregulated (387). Out of over 600 herbal medicine products in circulation in 2014, only a little over 200 underwent preliminary phyto-chemical analysis and safety tests at the Centre for Plant Medicine Research in Mampong Akuapem in the Eastern Region (http://www.cpmr.org.gh/). Sequential and concurrent use of multiple types of treatments have been reported (85), although concerns about pharmacologic interactions between herbal and orthodox medications have been raised (388). In South Africa, some of the traditional medicines utilized during pregnancy were found to contribute to fetal distress and ruptured uterus, and some were even considered poisonous (165, 166).

The ongoing tension between orthodox and traditional approaches to childbirth must be resolved. The cultural rationale behind harmful practices needs to be identified and discouraged, and those that promote positive practices should be reinforced. There is an urgent need to investigate and document the pharmacologic effects of traditional herbs used during pregnancy and childbirth in Ghana. This should include labelling herbal medicines, their indications and side-effects in order to allow mothers to make informed choices. Currently there are over 300 registered herbal medicines in Ghana but none is included in the national essential drug list and a large proportion of herbal medicine manufacturers are unregulated small-scale industries. In addition, herbal medicines are easily available by self-prescription, over the counter, in buses, on the street and by house-to-house sales. The Ghana Standards Board, Food and Drugs Board and the Traditional and Alternative Medicine Directorate of the Ghana's Ministry of Health must ensure that policies regarding production, importation, licencing, sales, advertisement, and prescription of traditional medicines are strictly adhered to (389). Clinicians need to ask women about alternative drug use during antenatal clinic and also be knowledgeable about possible pharmacologic interactions in order to educate mothers accordingly.

7.10.2 Factors influencing where mothers sought maternity and neonatal care

Previous quantitative studies have noted many factors associated with place of delivery including socioeconomic status of mother, education, age, religion, possession of health insurance, distance to health facility, place of residence and availability of transport (79, 80, 99, 104, 108, 390). The social and cultural factors that influence mothers' choice place of delivery, however, remain under explored. This study showed that where mothers sought maternity services, including delivery and care for neonatal illnesses, was influenced by sociocultural structures affecting the decision-making process (L1a), a cultural preference for home delivery (L1a), the accessibility of maternity services (L1c/L2c) and their relationship with maternity care providers (L2d). Mosley and Chen classify the first two factors as household and community level socioeconomic factors and the latter two variables as proximate determinants, herein referred to as individual/family factors. In the current model, I show that the relationship between these societal (L1) and personal/family (L2) variables and neonatal mortality is mediated by where mothers seek maternity services (L3).

The interviews showed that the collectivism of a medical team was replaced with women's consultations with people in positions of power, for example husbands, elderly relatives and religious leaders, not because they have expertise, but because of the societal scaffolding which dictates that men are in authority, and spiritual perspectives which dictate that God is in charge (L1a). These findings corroborate previous qualitative studies in Ghana which found that women's obstetric decision-making is a complicated process involving family hierarchy structures, their spouses, older female relatives and religious leaders (99, 100, 108, 391, 392). As previously reported by Jansen (100), women and their spouses were reported to consider the economic consequences (L1b) of maternity services, and the risks, interests and advantages in relation to their cultural, spiritual and social systems (L1) when deciding on the place of delivery. In other cultures, women required permission from their husbands or compound heads (108). This shows that maternal and child health promotion activities targeted solely on mothers or pregnant women is short-sighted and the availability of maternity services does not guarantee usage if underlying sociocultural structures (L1) and patterns are not addressed. The differences in gender-culture dynamics and distribution of power between different cultures imply that these findings ought to be carefully transferred to other contexts (112, 392).

It will be interesting to explore the interaction between factors at the societal level (Level 1) - culture, economic, physical and health care system - and those at the individual/family level (Level 2) - maternal demographics, personal beliefs and place of residence. For example, which of the societal factors (L1) were more important in influencing the place of delivery? And at the individual/family level (Level 2), how does obstetric decision-making differ between women of different demographic characteristics (L2a). While these questions may be a digression from the primary aim of the current study, it seems that if the social benefits of home deliveries outweighed the economic costs of facility deliveries, in women's estimation, they delivered with TBAs. This is evident by the high proportion of women who seek antenatal care services compared to facility-based delivery. It thus seems that women appreciate some of the benefits of facility-based care (108), and so seek antenatal care services to ensure a healthy pregnancy, which then provides justification for home delivery (100).

This study showed that the sociocultural (L1a) definition of a 'strong woman' was very influential in determining where women sought delivery services (Strong in this context refers more to physique rather than 'power'- it has already been shown that women were powerless in the decision-making). This is consistent with ethnographic studies in central Ghana which show a high social value associated with home deliveries (99, 100). On the contrary, in-depth interviews and focus group discussions (FGD) in northern Ghana reported that such cultural beliefs have changed and "every man or woman knows how clinic delivery is very relevant and safe" (108). The authors noted that a few years ago, home deliveries were highly regarded in northern Ghana but the region is undergoing a cultural transition. During the current study, home delivery in northern Ghana had been banned, and TBAs had become obsolete. This shows that cultural perceptions are amenable to change if targeted educational programmes are implemented. Maternity care providers in this study reported a general fear of surgery among women (L2d), which may make hospital births less desirable. In addition, churches were reported to increase these fears by demonising surgery (L2d/L1c). The multiplicative effect of this meant that women resorted to deliver at home where there was no option for assisted delivery and those who went to hospitals returned home after being told to go for surgery, usually after consulting with her husband or pastor (L1a). In these communities, it was also believed that evil forces, extra-marital affairs, misattribution of child's paternity could cause difficult delivery, and thus warranting a hospital delivery or interventional delivery (78, 80). There are clearly common misunderstandings of the causes of obstetric complications and misperceptions about caesarean section among TBAs and pastors, and maternal health outreach should therefore include families, communities and churches (L1).

In the Moyer et al., (108) study in northern Ghana, community health nurses said that they encouraged women during antenatal care and told them of the benefits of delivering in the clinic or hospital but participant observations in central Ghana (99) noted that midwives spent very little time with mothers during ANC and mothers did not ask many questions because they did not want to waste nurses' time. In the current study, midwives did not discuss birth plan alternatives with mothers prenatally, unless there was a clinical indication. Decisions about surgery were therefore often announced intrapartum. Women may not have sufficient information or time to make decisions about surgery, thus consulted their husbands or pastors. An exploration of how intrapartum decisions are negotiated between women and clinicians would be interesting. The results of the current study show that clinicians may mitigate possible spousal interferences if prenatal counselling addresses underlying cultural or religious perceptions (L1a/L2d) regarding childbirth, especially surgery.

The differences between urban and rural (L1c/L2c) women in accessing skilled maternity services in developing countries are well known (27, 323). This study revealed that women who made the difficult journey to the hospital were sometimes turned back because they were not yet in active labour (99). Midwives refused to admit women who were not in active labour due to insufficient hospitals beds (L1d). During the interviews, it was observed that most maternity wards are full, with some patients lying on the floor. Turning away women to reduce traffic in the maternity ward, however, is insensitive to the plight of rural women who may have travelled long distances. It also encourages these women to stay in the house until labour is very advanced. Midwives were fond of complaining that women do not attend facilities on time. The sudden onset of labour (L2b) has also been found to contribute to home deliveries (80). It was also reported that midwives stayed in their facilities expecting women to come to be delivered but TBAs moved to women's homes to conduct delivery (L3abc/L2c), especially in cases where conditions did not allow the labouring woman to be transported. There is a clear need for innovative ways to deliver maternity services in hard to reach rural areas in Ghana, as facility-based services are currently insufficient to meet newborn needs. Given the difficulties in training and keeping midwives in rural facilities, policies aimed at removing geographic barriers (L1c/L2c) to maternity services should consider expansion of the CHPS model to include allocating community midwives within rural areas (393-395). These community midwives should be skilled enough to attend basic deliveries in women's homes, identify high risk deliveries and follow through with appropriate referrals (L3).

Many authors have written about maltreatment (L2d/L3), including verbal abuse, discrimination and neglect, meted out to women in Ghanaian hospitals and clinics (79, 99, 100, 331, 396). Bradley et al., (88) observed that care in hospitals and clinic was facility-centred rather than women-centred (L2c/L3abc). Midwives (L3ab) focused on the technical aspects of the delivery, such as posture, in the process 'medicalising' the delivery process. TBAs (L3c), on the other hand, appear to emphasise the psychological aspect of the delivery by supporting women emotionally. In Australia, it has been noted that some women preferred to be delivered by unregulated birth workers because they felt mainstream care by midwives was "traumatising and inflexible" but the unregulated birth workers respected them and supported their philosophical view of delivery (397). The choice between the medical care by midwives and psycho-social care by TBAs is not mutually exclusive and it is possible to blend the social and medical models of health. There have been calls to increase demand for skilled services through sound policy strategies that include "training of health providers in communication and counselling of pregnant and labouring women" (99).

Mothers in this study were reported to prefer to be delivered by people they knew, rather than '*strangers*' (L2d). 'Knowing' referred to care providers whom women could culturally identify with. TBAs were reported to be more culturally aware and sensitive than midwives in clinics and hospitals. For example, cultural values around childbirth, including seclusion and collection of birth totems like placenta, were ignored by midwives but upheld by TBAs. Many Ghanaian cultures encourage secrecy during pregnancy because pregnancy is considered a vulnerable period for both mother and child and beliefs that people with malevolent intents can bewitch the baby in utero or the immediate post-partum period are common (78, 79, 99). Newborn babies are therefore usually kept in seclusion for one week, or until the umbilical cord stump has fallen off, when it is believed the baby is old enough to be seen by other people (80). The dormitory settings in most Ghanaian hospitals or clinics allow other patients to see newborn babies, and mothers were more likely to be seen by more than a single care provider. TBAs said they did not allow anyone to be present during labour, unless the woman wanted a relative around. Beliefs around the ritual disposal of placenta are common in Ghana and Tanzania (79, 100). Health care providers must also be sensitive to the cultural needs of each woman, if they intend to make skilled birth appealing to local women.

7.10.3 Managing serious neonatal illnesses

The management of neonatal complications varies greatly between maternity care providers in Ghana (L3abc) and the type of treatment administered is a product of the maternity care provider's beliefs and understanding of the disease aetiology and their skillset and the availability of equipment (L3abc). This study concurs with previous studies which showed that TBAs had insufficient knowledge and skills to manage obstetric complications and neonatal diseases (80, 95). They did not have the necessary equipment to identify high risk deliveries. For example, some who knew that they didn't have the skill to deliver first births or teenage mothers said that mothers begged them for help because they could not afford to go to the hospital or clinic (80). Clinics had relatively better equipment for delivery and managing simple neonatal illness but complicated cases were transferred to hospital.

African beliefs in the spiritual origins of diseases and its implication for health seeking behaviour for neonatal illnesses have already been discussed (L1a), and were shared by TBAs (L3c) in this study (78, 154, 398). Such beliefs, the 'neo-witchcraft mentality' as Akrong (399) puts it, are not restricted to TBAs only but deeply rooted in West African cultures, with implications for where mothers seek treatment for serious newborn illnesses (L3). On the other hand, midwives and doctors believed in the scientific causes of diseases. There is also a general perception that midwives and doctors treat physical diseases and TBAs treat spiritual diseases (85, 400). Therefore if mothers believed that the neonatal disease was caused by spirits, they took the baby to TBAs or other traditional healers but if they believed it was physical, then they considered a clinic or hospital. In Kintampo, it was reported that mothers first sought care for newborn illnesses among older family members and TBAs before orthodox methods from health facilities (154). The effect of such practices means delay in seeking skilled care for neonatal illnesses.

The most popular neonatal disease believed to be caused by spirits in this study is *asram*. It is believed to be transmitted when a person with evil intentions looks at the baby within one week after birth. Several authors have written about *asram* in Ghana (85, 153, 154, 400) and in East Africa where it is known as "*kijicho*"- the evil eye disease (79). It is characterised by a wide range of danger signs and it is believed that asram "*cannot be treated in the hospital*". Most mothers therefore consulted TBAs or traditional healers for treatment. The Ghana Health Seeking Behaviour project's (401) taxonomy of childhood illnesses identified 'not for hospital' as a category of disease for which informants believed there was no medical cure and thus treated with herbs. Such beliefs could be significant barriers to care-seeking in health facilities. Unfortunately, doctors and midwives in my sample were divided about the clinical definition of asram and others denied its existence. Understanding the medical causes of asram, diagnosing and treating it in the hospital may be an effective way to encourage mothers to seek care for serious newborn diseases in health facilities

(153). Mothers also need to be encouraged to look out for danger signs in newborns to report to health facilities.

It was reported that TBAs managed preterm babies at home by encouraging warmth and limiting exposure, but some managed “active” preterms as they would term babies including bathing practices. While keeping babies indoors or wrapping them may be helpful in maintaining warmth, it also limits the ability to monitor skin changes for conditions like jaundice which is common in preterms, or thorough assessments in the early neonatal period. As reported in a previous study in Tanzania, TBAs in this study believed that babies born at seven months gestation could survive but those born in eight months could not (80). Such a paradox has, surprisingly, been noted in some scientific writings (402) but empirical studies show that late preterms have higher survival rate than early preterms (270, 271). Whatever the reason, prematurity is a high risk for neonatal mortality and facility-based care should be encouraged as TBAs do not have the skill or equipment to manage such cases.

TBAs used crude non-evidence-based measures to revive asphyxiated babies and herbal concoctions to treat neonatal infections. As in Tanzania, TBAs in this study cleared the airway of babies with cloth or sucked with their mouth (80) and resuscitated babies using improvised devices. These devices are ineffective in clearing lower airway congestions or resuscitating severely asphyxiated babies and the TBAs did not also mention proper positioning of the babies before resuscitation. Other traditional methods to revive unresponsive babies included drumming and pouring cold water over the newborn baby which does more harm than good. In Tanzania, some TBAs “immersed baby in cold water up to the neck” (80). First, pouring cold water over the baby exposes them to hypothermia, but even more worrying is the risk of drowning.

The use of herbal medicine for neonatal infections has been reported in past studies (79). With continued use, the efficacy of these herbs could be assumed but without proper scientific justification, the consequences for using herbs on neonates could be dire. Babies do not have well developed organs to metabolise active ingredients in these herbs which could lead to complications. Unfortunately, the pharmaco-activity of many of these herbs is unknown (165-167, 403). Some TBAs in this study said they asked mothers to take newborn babies to the hospital or clinic following delivery, usually for oral polio vaccine and Bacillus Calmette-Guérin (BCG) tuberculosis immunisations which are given on the day of birth. This means that midwives would have an opportunity to see newborn babies within the early neonatal period. However, given that most birth asphyxia occurs in the perinatal period (5, 404), this means that most asphyxiated babies are managed by TBAs before they are taken to hospital, and since most neonatal infections occur in the late neonatal period (5), this implies the window of opportunity is missed. This study calls for urgent programmes to increase access to skilled care services- including postnatal visits by community health nurses (405). If integration of TBAs into formal health systems is desirable, then further investigations into their activities, and its implications for their training and roles should be considered.

TBAs have historically been trained to support maternity care delivery in developing countries, although the value of such training schemes remain controversial today and plausible arguments are made both for and against them (95, 406). Empirical studies suggest that training TBAs may lead to cleaner home deliveries, increased knowledge and better attitudes of TBAs, with moderate improvements being found. However, some results were inconclusive (94-96, 406). Their original roles included conducting safe basic delivery, identifying and referring high risk cases, and promoting antenatal and family planning services. Despite the clarity of these conditions, many TBAs routinely deliver high-risk cases they have been taught to refer, because patients refuse to attend a health facility citing financial difficulties, a lack of transportation or the poor attitude of midwives (309). On the one hand, it could be justified that without TBAs, mothers would have no one to attend to them, but delivering high risk pregnancies for which TBAs have neither the equipment nor skill may worsen pregnancy outcomes. Some TBAs were reported to keep mothers too long, only to refer them when it was too late.

Midwives in CHPS facilities had basic equipment to conduct safe deliveries and manage mildly asphyxiated babies but they did not have drugs to manage babies with severe asphyxia or those with infections. The latter were therefore transferred to nearest higher facilities. Midwives, however, could not follow up on mothers to ensure they did follow through with transfers, and some mothers were reported to resort to traditional approaches. The difficulties in being transported from villages to health centres or hospitals and inefficient referral systems have previously been discussed (407, 408). In the Brong Ahafo region of Ghana, it has been noted that treatment is sought for only 61% of all episodes of serious neonatal illness, and of these only 39% of these consult a doctor in a hospital (154). Difficulties in obtaining transport from villages and CHPS centres to health centres or hospitals can undermine the CHPS concept and efforts should be put into improving rural transportation and referral systems. Midwives in CHPS compounds may also benefit from some training to provide community based care for newborns with minor ailments.

In hospitals, midwives and doctors had sufficient equipment and drugs to manage complicated deliveries and all sorts of neonatal diseases although treatments were typically based on symptoms and rarely on laboratory investigations. Preterm babies were managed in intensive care units, asphyxiated babies were resuscitated and babies with infections were treated with antibiotics. All the hospitals complained of a lack of specialists, and inefficient referral systems because of lack of suitable transport and receipient hospitals complained of lack of space. Overall, maternity care providers in Ghana said that the most difficult part of managing newborns was resuscitating an asphyxiated baby, indicating the need for further training and support.

7.11 Conclusion

This study showed important sociocultural and individual/family level factors which influence where mothers seek maternity services and their outcomes. Women's choice of where to deliver or seek care for neonatal illness is not only dictated by access to maternity service or costs of services, but also a combination of factors including social structures around obstetric decision-making, the perceived attitudes of maternity care provider, culture and local illness beliefs. In maternity care practice, the management of birth complications depends on care providers beliefs and skills, and this ultimately influences neonatal outcomes. This study thus calls for an improvement in conditions that influence facility-based deliveries and promotion of facility-based care. It is unlikely that interventions focusing on a single aspect of these factors will yield any significant outcomes. Neonatal interventions and programmes should therefore consider addressing both societal and individual/family causes of neonatal deaths which ensure that all mothers are delivered by skilled personnel in a safe environment and all sick babies receive the necessary treatment from a skilled provider.

7.12 Strengths and limitations

It is common for researchers investigating neonatal mortality to analyse data on mothers and their babies. As seen in chapters four and five of this thesis, the value of such analyses in determining the factors associated with newborn deaths and the size of their effects cannot be overemphasised. Any efforts to improve newborn health and practice will, however, require a multiple stakeholder approach, particularly the involvement of maternity care providers, whose voices, unfortunately, are largely missing from the discourse (88). This study fills that gap and, provides a context and a framework for understanding the factors associated with neonatal mortality.

Data on local birth practices are key for designing culturally acceptable newborn policies, but there is a paucity of information on such practices. Major surveys including the Demographic and Health Survey do not routinely collect these data. This study adds to the small but growing body of evidence on cultural and birth practices associated with neonatal mortality in a developing country context. My study covered rural and urban areas, and distinguishes clinics from hospitals. Previous studies used the term health facility to cover both clinics and hospitals, without considering the difference between a community based clinic with no doctor and a hospital with access to a doctor.

The analyses of the interview data may have suffered some data loss during the translation into English of interviews conducted in Akan and Dangbe. I believe some nuances in meaning may have been lost but these would not have been enough to change the major findings in this study. To mitigate such a possibility, the research assistants who helped during those interviews were both healthcare providers and native speakers and so were familiar with the maternal and child health terminology. The translators were professionals with long years of experience. The use of professional midwives as research assistants could have prejudiced the type of questions they asked TBAs or their colleague midwives but this was reduced by providing a questionnaire guide and training before starting the interviews (409). I was also physically present during all interviews, including those conducted in Dangbe to ensure adherence to the protocol. Post-interview discussions with the research assistants also helped to clarify any concerns they might have had.

The sample in this study included only maternity care providers who experienced adverse neonatal outcomes – prematurity and low birthweight, asphyxia, infection and neonatal death. It excluded those who did not experience the adverse outcomes because their views were sought in questionnaire survey in Chapter 6. Future studies should also consider exploring the views of mothers, family relations, spouses and religious leaders regarding childbirth and care of the newborn. This study did not collect information on how maternity care providers in Ghana managed congenital malformations, although it is part of the conceptual framework, because of the non-specificity of the origins of congenital malformations and often there is little care providers can do to improve them. I could not present comprehensive information on the physical environment (Level 1c) within which births were conducted but the little evidence from Fig. 7.6 suggests that the home environment was less condusive compared to a standard health facility. Although this study covered a small number of maternity care provider related newborn practices, and the remit of a qualitative interview does not allow an estimation of the prevalence of the individual birth practices in the population, the results show that TBAs are more likely not to follow recommended guidelines. Given that TBA practice serves a substantial proportion of women, this study emphasises the urgent need to increase skilled maternity services at the community level in order to improve neonatal health.

Chapter 8: Summary of Findings, General Discussion and Conclusion

8.1 Introduction

This is the final chapter of the thesis. The previous four chapters presented results from analyses of data on mothers and their babies in Ghana and Scotland (chapters 4 and 5 respectively) and maternity care providers in Ghana (chapters 6 and 7). These provide multiple perspectives to help understand the factors associated with neonatal mortality in Ghana. The findings have also been summarised in a conceptual framework (previously presented in Fig 7.5 and re-presented here). It is important to highlight that the aim of this chapter is to draw attention to, and critically interpret, the key differences between Ghana and Scotland in terms of NMR, distribution of neonatal mortality and causes of deaths (objective 5, Section 1.4). This is followed by a summary of the strengths and limitations, and recommendations of the overall thesis. Detailed discussions of the various results chapters, together with their strengths and weaknesses, have already been included in the previous sections (4.7, 5.5, 6.4 and 7.11).

8.2 Summary of key findings

Table 8.1: Summary of key findings and recommendations from data chapters

Chapter	Aims	Findings	Recommendations
4	Determine and compare the NMR in three regions of Ghana	The combined NMR in the three HDSS was 12.0 (Navrongo: 18.8, Kintampo: 12.5, Dodowa: 6.2).	Further studies should explore the individual contributions of interventions to the reduced NMR in the HDSS, and explore other programmes that could sustain the decreasing NMR Improve access to skilled care for neonatal illnesses: community care for newborn illnesses especially infections, efficient referral and emergency systems. Encourage mothers to seek early treatment for neonatal illnesses. Replace home births with clinic births and equip
	Determine NMR trends	The NMR in all three regions is reducing, especially among hospital and home births	
	Determine the distribution of neonatal deaths by time and cause of death	More than 70% of neonatal deaths occurred in the first week and the major causes of death are asphyxia (23%), prematurity (13.5%) and infection (26.3%). Asphyxia was the leading cause of early neonatal deaths and infection was the leading cause of late neonatal deaths Most neonatal deaths occurring at home were due to infection and the leading cause of death in hospital was asphyxia	

		There were excess deaths among hospital births at home	hospitals with equipment to manage high risk deliveries. Train skilled care providers in management of asphyxia, especially resuscitation techniques.
	Determine the factors associated with neonatal mortality in Ghana.	Hospital births are a significant risk for neonatal mortality, largely because hospitals may not have equipment to manage asphyxia or hospital births were discharged home too early. Boys, no maternal education, and primiparity are associated with higher risks for neonatal mortality. Twin births had the highest risk of neonatal mortality	
5	Determine NMR in Scotland	NMR among singletons in Scotland was 2.2	Focus on interventions to reduce early neonatal deaths as this will also influence late neonatal deaths Current measures should be implemented to improve premature births, especially the extremely premature babies. Clinicians should pay special attention to mothers with a history of a neonatal death as a risk for another neonatal death. Public health education and smoking cessation programmes, especially for pregnant women should be intensified.
	Determine trends in NMR	NMR of singletons in Scotland declined by 62.5% from 3.2 in 1992 to 1.2 in 2015	
	Determine the distribution and causes of neonatal deaths	Almost all neonatal deaths occurred in the first week and 61% of these occurred on the day of birth. The leading causes of neonatal death were: congenital malformations (29.1%), hypoxia or birth asphyxia (23.5%), prematurity (15.4%) and maternal complications (11.6%). Infections were responsible for only 3.4%	
	Determine factors associated with NMR	Boys, low APGAR score, prematurity and low birth weight were significant risks for neonatal mortality. Mothers with previous neonatal mortality and first time mothers had a higher risk of neonatal death. Mothers who smoked had a higher risk of neonatal mortality.	
6	Describe characteristics of maternity care providers and types of maternity services in Ghana	Maternity care services in hospitals and clinics are provided by doctors, midwives and nurses who are formally trained, but home delivery are conducted by unskilled TBAs TBAs are older and have longer years of overall practice experience but less education and smaller throughput compared to doctors and midwives	Improve community access to skilled maternity services through expansion of CHPS facilities to include maternity care providers. Train and equip midwives in clinics to manage minor neonatal illnesses Skilled care providers in hospital and clinic require some communication

		TBAs were more accessible in communities than clinics or hospitals	skills, and their practices should be receptive to culture of women in labour, within the limits of safe medical practice. Improve facilities in hospitals to manage advanced neonatal complications especially asphyxia, prematurity and infections.
	Describe the birth practices of various maternity care providers	TBAs had rudimentary equipment to manage birth complications and some of their birth practices predisposed babies to infections. Women were attracted to their services because of their cultural understanding and provision of emotional and spiritual support. Clinics were ill-equipped to manage birth complications, except birth asphyxia. They referred most of their cases to hospitals Hospitals had insufficient facilities to manage advanced neonatal illnesses, and they did not have a specialist.	
7	Provide a contextual understanding (culture and birth practices) of the factors which influenced neonatal mortality in Ghana	Significant differences in birth practices were observed among maternity care providers in Ghana: trained care providers followed recommended guidelines amidst logistical limitations, but TBAs used traditional approaches which were potentially detrimental. Neonatal mortality in Ghana was largely influenced by where mothers sought maternity services. Mothers' choice of place of delivery or place for seeking care for newborn illness were influenced by: socio-cultural practices and values, financial constraints, mothers' level of autonomy, beliefs about origins of disease, access to maternity services , and attitudes of maternity care providers. Babies delivered or managed by skilled personnel, in hospitals or clinics, received better treatment but those managed by TBAs at home were cared for using traditional approaches which were potentially harmful.	Newborn care recommendations should be an integral part of current maternal and child health policies at both facility and community level ANC education should include discussions about birthing plan to allow mothers make informed decisions about place of delivery and identify possible barriers. Maternal and child health promotion activities should be targeted at women and other people who influence her obstetric decision-making process Improve access to community maternity care by expanding CHPS facilities to include midwifery and basic care for newborn illnesses

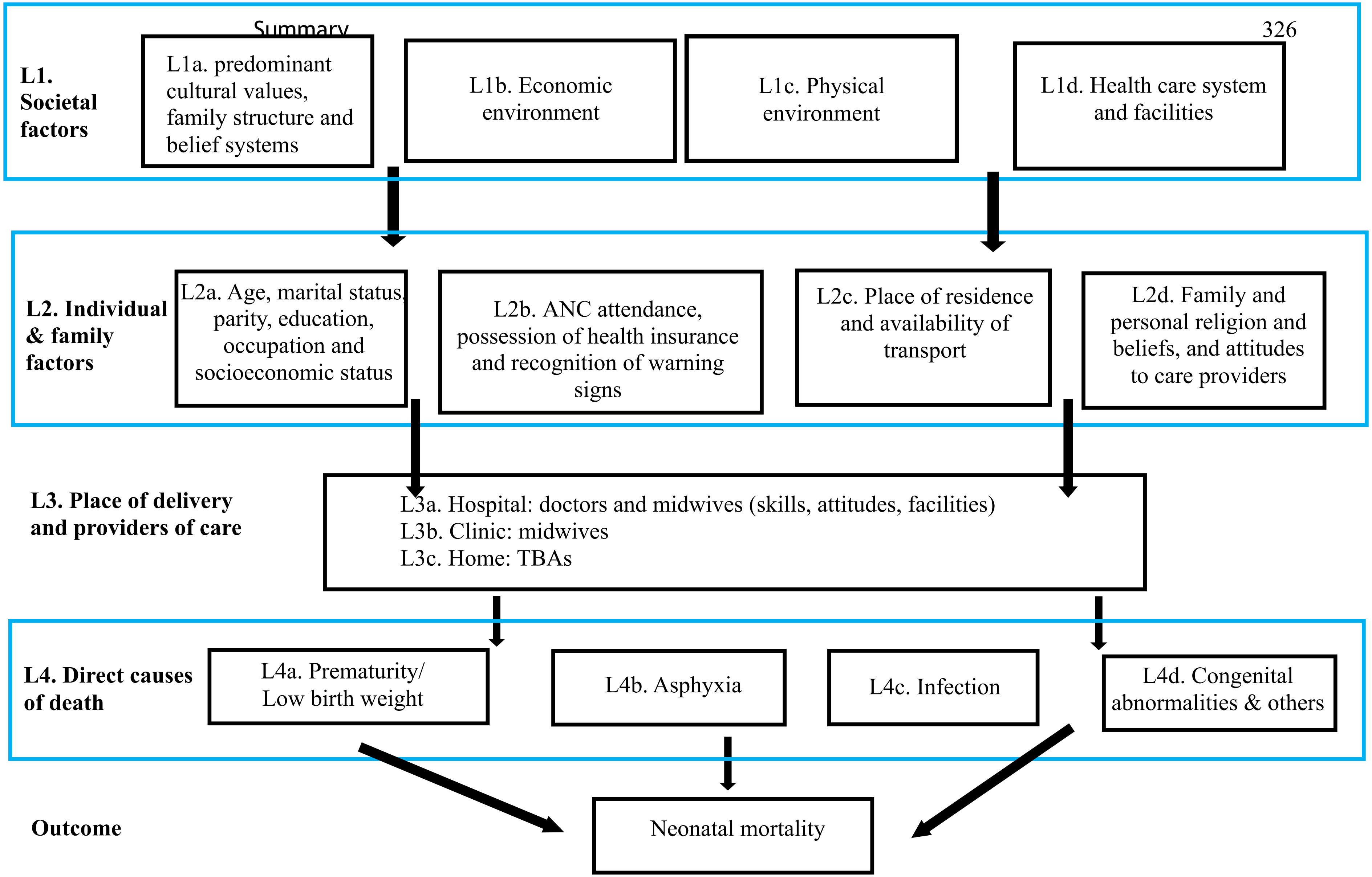


Fig 7.5: A conceptual framework for neonatal mortality in Ghana

Box 8.1: Contribution of the thesis

This thesis provides multiple perspectives to understanding the factors which are associated with neonatal mortality in Ghana. It is one of the few studies to analyse the distribution of neonatal mortality and causes of neonatal death in Ghana by place of birth/place of death. It was shown that babies born in hospital had an increased risk of death compared to home births. The majority of these deaths especially among babies who were born in hospital, occurred at home and in the first week, and the main cause of death was infection. For babies who died in hospital, the main cause of death was birth asphyxia. This thesis was, therefore, able to quantify the excess mortality among hospital births that occur at home with corresponding important implications for policy and practice (discussed later). In terms of methodology, this illustrates a better way of understanding risks of neonatal mortality in developing countries.

By interviewing experienced maternity care providers in Ghana, this thesis adds to the growing body of evidence on the characteristics of maternity care providers, birth practices and cultural practices which may be associated with neonatal mortality.

Finally, by directly comparing the distribution of neonatal deaths and their causes between Ghana and Scotland, this thesis identified priority areas and potential interventions which could be implemented to improve newborn health in Ghana.

8.3 Discussion

8.3.1 NMR is five times greater in Ghana than in Scotland

The combined NMR of the three HDSSs in Ghana is 11.9, which is five times greater than the NMR in Scotland (2.2). Given the possibility of under-reporting of neonatal deaths in the HDSS samples, especially in Dodowa, the true NMR for the Ghanaian data may well be higher (discussed earlier in section 4.7.1). On the other hand, as the Scottish data did not include multiple births, it too is an under-representation, although published figures suggest that adding the multiple births would only increase the Scottish NMR to 2.7. With possibly the most complete data being provided by Navrongo, which had an overall NMR of 18.8, it is thus safe to assume that the NMR in Ghana is at least five times that of Scotland. This is not surprising, and in some instances, the difference in the published NMRs between other high and low- or middle-income countries is more than 10-fold (262). The Scottish NMR reported in this study was based on about 98% of births occuring in the study period, but the Ghanaian rate is based on five of 216 districts. The five districts represent a geographically diverse population but, nonetheless, is not nationally representative. It has already been noted that the NMRs in the three HDSSs in this thesis is lower than the estimated national rate (Ghana=29 compared to Scotland= 2.7) for reasons explained previously (section 4.7.1). Yet even if we accept the combined NMR of 12 observed from these three areas, the NMR in Ghana is still greater than that of Scotland in 1977 (13).

Many reasons could account for the significant differences in NMR between Ghana and Scotland: differences in demographic characteristics (L2a), the quality of healthcare systems (L3abc) and neonatal care provision (L3abc/L4), the availability of and accessibility to advanced neonatal care (L1d/L3abc/L4), and high quality emergency services (L2c/L3abc) (13, 30) (125), culture and newborn care practices (L1a/L2d). As shown in a previous American study (410), ethnic or racial differences in NMR exist between Black and White in the US. Although the risk of death among preterms and babies with low birthweight was lower among Blacks, Whites (0.35) and Hispanics (0.45) had significantly lower overall NMR than Blacks (8.16). The study was descriptive and so it is likely that these differences could be confounded by other socioeconomic variables. Another study in the Netherlands noted that the babies of African women were at a significantly higher risk of early neonatal death compared to their Dutch counterparts (411). In 2016, Ghana's GDP per capita was USD 1,513 (UK= USD 39,900) and the health expenditure per capita in 2014 was USD 58 (UK= USD 3,935) (https://data.worldbank.org/indicator/). Thirty-seven percent of the Ghanaian women who delivered in the study period had at least four children and 7.4% were over 40 years of age, compared to only 3% of mothers in Scotland who had four or more children and only 2.6% who were at least 40 years old.

In Scotland, the widespread availability of well-resourced neonatal intensive care units (NICU) and advanced resuscitation equipment in hospitals, increased use of surfactant and widespread use of corticosteroids by mothers with threatened preterm labour was followed by large reductions in NMRs in the early 1990s (13). In other high-income countries, advances in prenatal and intrapartum monitoring of hypoxia, caesarean sections for fetal distress, clean delivery practices and use of antibiotics were noted to have contributed to declines in NMR (30, 65). In Ghana, like other countries in sub-Saharan Africa, not all hospitals have NICUs and maternity and neonatal units in clinics and district hospitals are ill-equipped (125) (126). None of the hospitals in this study had a qualified neonatologist, there were no doctors or NICUs in community clinics, surfactant was not readily available, shortages of basic drugs were common (Detailed discussion in Chapter 6), and attaining at least 60% of corticosteroid prescription for mothers with threatened preterm birth remains a hope for the end of 2018 (30, 38, 412)- the Ghana newborn strategy and policy action is discussed later. A significant proportion of births and newborn complications are also managed by personnel who do not have the skills or equipment to do so safely and effectively (125) (126).

This thesis found a high rate of neonatal mortality among babies born in hospital, compared to clinic and home births in Ghana. It has been shown that this was likely due to deaths which occurred at home, including mortality among babies who were born at home and also died at home (home/home), and those who were born in hospital but died at home (Hosp/home). This could be because babies were discharged too early without diligent postnatal checks, postnatal home visits were inadequate or mothers did not seek early treatment when their child became ill. The Scottish data did not contain information on place of death so direct comparisons are limited, but anecdotal evidence suggests that mothers in Ghana often sought alternative care for neonatal illness and only reported to the health facility when it was too late. The cultural differences in newborn care between Ghana and Scotland are discussed later. Financial and geographic barriers to seeking care in Ghana are well known (99, 109, 322, 413).

8.3.2 Early neonatal mortality is a priority in Scotland but in Ghana both early and late neonatal mortality are of concern.

In Scotland, almost all (99.5%) deaths occurred in the first week (61% of which occurred on the day of birth). This compares to Ghana where 73.8% of all neonatal deaths occurred in the first week (less than half occurred on the day of birth) and a quarter died after the first week. This contrast is important given the differences in aetiologies of early and late neonatal deaths (discussed later). The higher proportion of neonatal deaths which occurred in the first week in Scotland (eNMR= 2.2 per 1,000 livebirths) but negligible proportion who die in the late neonatal period (lNMR= 0.009 per 1,000) suggests that reducing early neonatal deaths is now the priority in Scotland. In Ghana, however, although the majority of neonatal deaths occurred in the first week (eNMR=8.8), the proportion of deaths which occur in the late (lNMR=3.1) neonatal period suggests that both periods deserve attention. In Scotland, there were no neonatal deaths after the eleventh day of birth but in Ghana, there were deaths throughout the neonatal period. Deaths in the early neonatal period are usually related to perinatal activities and late neonatal deaths to postnatal care. Therefore postnatal care is an obvious area to shift attention to reduce NMR in Ghana nearer to Scotland.

8.3.3 Decision about place of delivery in Scotland is based on clinical risks but in Ghana it is influenced by sociocultural and individual/ family factors

In the UK, decisions about place of delivery are largely informed by the clinical risks associated with the delivery (157). Midwives basically assess the pregnant woman and discuss the birthing plan based on the risks associated with their pregnancy. Women who are considered to be at low-risk including those with no medical conditions, no current obstetric risks or previous birth complications may choose to deliver in a freestanding midwifery unit or at home, but women considered to be at high-risk are advised to deliver in an obstetric unit in a hospital. Information on the benefits or risks associated with each choice is given to women so that they can make an informed choice and receive needed support. The ultimate decision, however, remains that of the woman to make.

Guidelines for intrapartum care including place of delivery have been published (157).

There are no standardised guidelines regarding where mothers in Ghana deliver babies. In Ghana, women's choice of place of delivery is complicated and largely influenced by societal factors (Level 1) and individual/ family factors (Level 2). As previously reported by Jansen (100), women and their spouses considered the economic consequences (L1b) of maternity services, the risks, interests and advantages in relation to societal structures and cultural values (L1a). Cultural beliefs (L1a/L2d) such as beliefs that women who were delivered in a hospital or clinic were weak, or those who delivered at home were strong, and those who experienced a difficult delivery may have committed a sin also discouraged women from delivering in a health facility. Other factors which influenced maternity decisions were perceptions about the attitude of maternity care providers (L2d), accessibility to a health facility (L1c/L2c) and costs of maternity care (L1b/L2a). Women who lived in rural areas had to travel longer distance to access maternity care in a health facility and there were difficulties accessing transport. Similar findings have been reported in Bangladesh (327). Although maternity care in Ghanaian health facilities is supposed to be free, this study found that there were several indirect costs. In Scotland there is an efficient ambulance service system and maternity services is free at point of delivery. Other cultural and contextual factors that influence where mothers seek delivery services have been explained in the previous chapter (See Fig 7.5).

8.3.4 Maternity care in Scotland is provided by skilled professionals, but in Ghana a significant proportion of births are conducted by unskilled providers

The 1902 Midwives Act in the UK outlawed deliveries conducted by uncertified-and-untrained midwives (handywomen) and certified-but-untrained midwives (bona fide) (76). The Act was a major milestone in midwifery training and supervision; midwives were required to have training and to call on a doctor in case of complications. Those without qualifications or certifications were allowed to continue to practice under some conditions until about 1947 but they could not recover any fee or charge for birth attendance. Today all births in Scotland are attended by trained professionals.

Home delivery in the UK is rare; only two percent of babies in Scotland are currently delivered at home and 98% of all newborn births occur in health facilities (414). Furthermore all of these births in Scotland, including home births, are managed by skilled personnel, with back-up by a skilled medical team via ambulance. This compares to Ghana where 73% of deliveries occur in health facilities (10). In this study, 60% of deliveries in the HDSSs occurred in health facilities (38% of the total births occurred in hospitals) and 40% occurred at home. Home deliveries in Ghana are managed by TBAs who have no formal training, use very rudimentary equipment and transfer systems are not well developed (L3). The characteristics of TBAs and how they conduct deliveries have been described (77).

There were significant differences in the management of newborn complications (Level 4) between Ghana and Scotland. While treatment of birth complications in Scotland was more homogenous, in Ghana, it depended on the type of maternity care provider (Level 3). As in Scotland, midwives and doctors in Ghana used orthodox methods, although in Scotland facilities were much better resourced. In Ghana, TBAs used traditional approaches for which there is no evidence of effectiveness and some of which could be harmful to newborns (159). These traditional approaches, for example using herbal concoctions to dress the umbilical cord stumps or to treat neonatal infections, are rooted in widespread cultural beliefs that the herbs made the cord heal faster and that some newborn illnesses were caused by spirits and thus could only be treated with herbal medicines (153, 154, 401). Unfortunately, these approaches predisposed babies to infections and a previous study in Ghana noted increased mortality due to infections among babies who died at home (59). Such beliefs and practices are extremely rare in Scotland, and all sick babies are treated by trained health personnel in more standardised and controlled clinical settings, using standardised guidelines (157). I did not have separate data on home births in Scotland to compare causes of death or NMRs but as the choice of home delivery is usually based on an assessment of low risk, there is no reason to believe these will be higher than the overall Scottish rates.

8.3.5 There is increased risk of death due to prematurity, asphyxia and infection in Ghana compared to Scotland.

In Scotland, congenital malformations (29.1%), intrapartum hypoxia or birth asphyxia (23.5%) and prematurity (15.4%) were the leading causes of death. Infection was responsible for only 3.4% of overall neonatal deaths. This compares to Ghana where the leading causes of overall neonatal mortality were infection (26.3%), asphyxia (22.8%) and prematurity (13.5%). This is consistent with global analyses which show that infections, asphyxia and prematurity are the leading causes of neonatal death in developing countries (272). While there may be little that clinicians or public health practitioners can do to prevent congenital malformations (275, 279), deaths due to infections are preventable or can be successfully treated with antibiotics (158, 336, 352, 415, 416). The proportion of neonatal deaths due to asphyxia and prematurity in Ghana and Scotland is comparable, but the NMRs attributable to asphyxia and prematurity in Ghana was much higher.

Table 8.2: Major causes of neonatal death and NMR in Ghana and Scotland (L4)

	Scotland	Ghana*
	N= 1,278,846 (NMR)	N=28,223 (NMR)
Cause of death		
All deaths	2,783 (2.2)	460 (16.3)
Congenital conditions	758 (0.6)	-
Intrapartum hypoxia/ birth asphyxia	614 (0.4)	105 (3.7)
Prematurity and low birth weight	402 (0.3)	62 (2.2)
Maternal complications	302 (0.2)	-
Haemorrhagic conditions	140 (0.1)	-
Other perinatal conditions	98 (0.08)	-
Perinatal infections	88 (0.07)	121 (4.3)
Others	381 (0.2)	172 (6.1)
NMR- Neonatal mortality rate		
*Results based on data from Navrongo HDSS and Kintampo HDSS		

Infection was the leading cause of overall neonatal mortality and late neonatal death in Ghana, but in Scotland none of the 88 deaths from infection between 1992-2015 occurred after the first week. When the NMR due to infections in Scotland (0.07 per 1,000) was applied to the population of livebirths in Navrongo and Kintampo, it was concluded that 119 deaths could have been prevented over the period of the study. This represents a 26% reduction in overall neonatal mortality in Navrongo and Kintampo and a reduction of the NMR from 16.3 to

12.1 (neonatal deaths in Dodowa was excluded because information on the causes of death was not provided). The significant difference in the proportion of deaths due to infection indicates marked differences in the quality of postnatal care, health seeking behaviour for newborn illnesses and management of birth complications between Ghana and Scotland (discussed in the previous section).

The exact causes of bacterial infections in poor countries is unknown, but the group B streptococcus bacteria are regcognised as important contributors to early onset sepsis (341). A large number of other infectious agents could also be responsible, particularly in developing countries, including tetanus, malaria, E coli, Strep pneumonia and syphylis (14, 57, 59). Interventions to prevent neonatal infections include preventing prolonged labour, prophylactic treatment for maternal colonization or premature rupture of membranes, appropriate cord care, sterile birth practices and tetanus immunisation (158, 336, 352, 415, 416). In Scotland, neonatal infections are treated by skilled clinicians based on appropriate investigations and guidelines published by NICE (417). In Ghana, the diagnosis of most neonatal infections is based on clinical features without laboratory confirmation. A recent systematic review and meta-analysis showed that in low and middle-income countries, compared to a physician's diagnosis of neonatal infection, other front-line health care providers diagnosed bacterial infections based on clinical manifestations with average sensitivity of 82% (95% CI 76%-88%) and specificity of 69% (95% CI 54%-83%) (418). The study also showed that while injectable antibiotics were rarely available, oral amoxicillin and cotrimoxazole were widely available and about a quarter of them were purchased without prescription. Given that community clinics in Ghana did not have the capacity to diagnose or treat neonates, mothers resorted to chemical sellers or TBAs at home for treatment. Beliefs that some newborn infections were caused by spirits are well known (L1a/ L2d) (153, 154). Some mothers therefore sent the babies to traditional healers for herbal treatment which were possibly not effective. Other birth practices which predisposed neonates to infections have been presented in the previous section.

The factors which led to significant reductions in NMR in Scotland have been previously described (13). These included the widespread availability of resources to manage advanced birth asphyxia- equipment for intrapartum monitoring of fetal wellbeing, surfactant therapy, and mechanical ventilation. This compares to Ghana where only 12% of deliveries are conducted by personnel trained in essential neonatal care and 19% are delivered in facilities with equipment or drugs for respiratory support (65). None of the hospitals in this study had equipment for advanced resuscitation and community clinics did not have oxygen. Doctors in the face-to-face interviews said they were in a dilemma about transferring sick babies to the regional hospitals because of the poor state of the ambulances and roads. In addition, 41% of deliveries were conducted by unskilled professionals in homecare settings and more than 70% of TBAs (L4c) rated their resuscitation skills on a Likert scale as very poor (Chapter 6). It has been shown that training maternity care providers in health facilities in neonatal resuscitation could prevent up to 30% of deaths among term babies with intrapartum-related complications and 5-10% of deaths due to prematurity (419). There is some evidence that community based resuscitation programmes are both feasible and effective in reducing intrapartum-related mortality in settings with high rates of home birth and delivery attended by community workers (65). Such programmes should, however, be organised in tandem with interventions to strengthen the health care systems and referral systems for post-resuscitation care.

It has been estimated that 128,000 babies are born preterm in Ghana every year and 7,900 of these die within one month (420). The major causes of death among premature babies include intravascular haemorrhage, respiratory distress, and infections. Management of preterm babies involves maternal corticosteroids, ventilatory support as well as surfactant replacement therapy and antibiotics for those who suffer infections (271, 421). Not all mothers who have a threatening preterm birth in Ghana receive optimal care. In hospitals, mothers may receive corticosteroids, rest and cerclage[2]. In community clinics such treatment options are not available and mothers may thus be transferred to hospital. According to TBAs, it was normal for babies to be delivered from seven months gestation and so they managed babies at home without access to the

[2] A procedure in which stitches are used to close the cervix during pregnancy to help prevent pregnancy loss or premature birth.

requisite interventions. For the preterm baby, post-delivery management includes maintenance of warmth, breastfeeding and antibiotics for infections. While some cultural practices that promote wrapping the baby to maintain warmth would favour preterm babies, other practices including early bathing would carry a risk of hypothermia. The lack of adequate resuscitation equipment and poor management of infections would decrease survival chances for the extremely preterm baby in clinics and at home. In the UK guidelines for diagnosing, monitoring, preventing or reducing the likelihood of a preterm birth, and treating or lowering the risks following a preterm birth are available at www.nice.org.uk/guidance/ng25 (422).

8.4 Conclusion

The combined NMR of the three HDSSs in Ghana is about five times higher than the NMR in Scotland. Almost all the neonatal deaths in Scotland occur in the first week after birth which is the highest risk period, but a quarter of neonatal deaths in Ghana occur after the first week which is largely preventable. While some causes of neonatal deaths, notably preterm and asphyxia, are common to both countries, infection is a common cause of death in Ghana but now rare in Scotland. There were excess neonatal deaths at home in Ghana, including those who were born in a health facility. It is unconscionable that babies born in hospital die at home, especially on the day they are born or in the first week. The majority of babies who are born at home also subsequently die at home. Asphyxia was the leading cause of death among babies who were born in hospital and died in hospital (hospital/hospital). Infection was the leading cause of death among babies who were born at home (home/home and home/hosp) and who were born elsewhere and died at home (hosp/home).

There were significant differences in the availability of and access to skilled maternity services, and management of neonatal complications between Ghana and Scotland. All births and neonatal complications in Scotland were managed by skilled healthcare workers and approximately 98% of these occur in well-equipped facilities, but in Ghana care was provided by a mixture of skilled and unskilled providers and 40% of births occur at home. In Scotland, access to advanced neonatal care is widely available and accessible, but in Ghana, comprehensive care for prematurity, severe asphyxia and neonatal infection was only available in certain hospitals. Management of birth complications at home was very poor and it increased baby's risk of death. The type of facility in Ghana in which babies are delivered and neonatal care provided was influenced by a complex interaction of societal hierarchical structures, cultural beliefs and practices, and individual and family factors (See revised conceptual model in Fig 7.5).

8.5 Strengths and limitations

8.5.1 Strengths

1. To my knowledge, this is one of the more comprehensive studies of neonatal mortality in Ghana ever conducted. It uses data from multiple sources about mothers, babies and healthcare providers, to examine the factors influencing neonatal mortality in Ghana, and by so doing it provides a better understanding of the demographic and contextual factors.

2. This thesis is one of the first to combine or compare data from all three geographically distinct surveillance areas in Ghana. These HDSS systems use apparently robust methods to collect birth and death data from the population. The thesis also presents a detailed analysis of the neonatal mortality data in Ghana. This helped to understand the characteristics and distribution of neonatal deaths and identify ways to improve newborn health.

3. It is generally agreed that health care delivery in developed countries is better than in developing countries, and this is often demonstrated by the lower mortality rates in the former. Direct comparisons between a developed and developing country are however rare. This study is one of the first to compare NMRs, causes of death and newborn care practices between a developing and a developed country in order to identify similarities and differences and make recommendations for improving neonatal health.

4. The thesis employed robust statistical techniques that allowed for the lack of independence between babies of the same household, and missing data.

5. The NMRs, causes of death and birth practices in Ghana were compared and contrasted with those from Scotland in order to identify birth practices in Ghana which could be modified to improve newborn health. It is necessary to note the differences in the methods used to diagnose deaths or classify the causes of neonatal deaths between the Ghana HDSS and Scotland.

8.5.2 Limitations

1. As previously described, the major concern regarding this thesis is the quality of some of the recorded variables from the Ghana HDSS. There were large amounts of missing data for variables such as ANC and mode of delivery, and in some cases data were available on only dead babies. As a result, some of these important variables could not be included in the multivariable analysis. There is also good reason to believe that some neonatal deaths may have been missed, consequently leading to lower NMR in this thesis.

2. Data from the three HDSS could also not be combined because of differences in the methods of recording the variables. This thesis analysed data from 2004-2014 but verbal autopsy data were available for only 2005-2010 which reduced the power of the verbal autopsy analysis.

3. An association between place of birth and neonatal mortality (in the Ghanaian HDSS data) does not imply causality as alternate explanations are plausible.

4. Cause of death information in the HDSSs was based on verbal autopsies which rely on recall by family members of the events which led to the death of the baby, normally without laboratory confirmation. A previous study assessing the accuracy of verbal autopsy in diagnosing neonatal conditions in Ghana found the following sensitivity/specificity scores for

birth asphyxia (74%/ 76%), infection (74%/ 87%) and prematurity (64%/ 94%) (421). In Scotland, diagnosis of neonatal death is based on full clinical, laboratory and sometimes post mortem data, which is the gold standard.

5. While the survey and in-depth interviews of maternity care providers provided insights into the conditions in which mothers were delivered and babies were cared for, the veracity of such information cannot be confirmed. To reduce the possibility of inaccuracy, I interviewed multiple experienced care providers.

6. It is possible that information from the in-depth interviews may have suffered some data loss due to translations from Dangbe and Akan to English. Such losses will largely be nuances in meaning but insufficient to alter the key findings of this thesis. I mitigated the effect of such data losses by recruiting midwives as research assistants since they were more familiar with the maternal and child vocabulary used by TBAs.

7. I could not combine the Ghanaian and Scottish data into a single file to explore the other risk factors for neonatal mortality due to the differences in the methods of data collection and how they are recorded.

8. Given that the Scottish data were based on singleton deliveries in health facilities only, I could not directly compare risk factors for neonatal mortality between Ghana and Scotland. In addition, several variables in the Scottish data were not collected in the Ghanaian dataset and an attempt to put the data together would have omitted all incomplete variables in a multivariable analysis. Specific methodological limitations have been previously described in the individual data chapters.

8.6 Implications of study

There is considerable scope for reducing newborn deaths due to asphyxia in hospitals and deaths due to infection at home. If the neonatal deaths due to asphyxia and infections in Ghana could be reduced to the Scottish level, nearly half (46.3%) of all neonatal deaths could be avoided. The knowledge and technologies needed to save newborn lives are available. What is required, according to Stefan Swartling Peterson (2017)- UNICEF's Chief of Health, "is to take them to where they are most needed" (423). Goldenberg and McClaure (30), emphasise that the most important questions are: a) how to make these interventions widely available with high quality of care and b) how to create a structure by which these interventions can be appropriately applied to all women and newborns in a timely fashion. This thesis suggests the following:

8.6.1 Implications for policy

1. Neonatal mortality in Ghana has been identified as a priority policy area with a policy objective to dramatically reduce the national NMR to 21 per 1,000 live births by the end of 2018 (38). Some of the plans to achieve this include: training at least 90% of all maternity care providers in essential neonatal care; increasing the proportion of deliveries by skilled personnel to 82%; reducing institutional deaths due to asphyxia by 50%; increasing antenatal corticosteroid coverage to 60% for mothers with threatened preterm birth; and increasing care seeking for neonatal illnesses to at least 80%.

   The Government of Ghana deserves commendation for showing leadership and commitment to improving newborn health. However, this thesis shows that unless urgent action is taken to translate these policies into changes on the ground, the Ghana National Newborn Health Strategy and Action Plan may fail to achieve the set objectives by the end of 2018. Only 60% of babies in the study areas were delivered by skilled personnel, many health facilities do not have the needed medications and by the end of 2016, the estimated NMR in the whole of Ghana was 27. There may therefore be the need to extend the deadline for the Newborn Health Strategy from 2018 to 2020, and in the intervening years, implement urgent actions to achieve set goals. There will also be the need to constitute a team at the Ministry of Health to monitor the implementation of actions towards these goals. There is every reason to believe that, if carefully adapted to Ghana, the interventions which helped improve neonatal health in Scotland and other similar countries will help reduce

NMR in Ghana substantially. New interventions introduced more recently are also available (365). Implementing and sustaining the set strategies require substantial funding, and government must make necessary budgetary allocation, or seek support from other development partners and philanthropists to support this policy.

2. Improving the quality of maternal and neonatal care is key to reducing NMR considerably in the study areas. Encouraging facility-based deliveries is important, but not sufficient, to 'dramatically' reduce NMR in Ghana. For emphasis, it should be repeated that increasing the proportion of births in sub-standard facilities will not reduce neonatal mortality rates. Babies must not only be delivered by skilled professionals, but also managed in good time by skilled professionals in well-equipped facilities at birth, and when they fall sick.

   This thesis shows that increasing the quality of care in all health care facilities is desirable, but prioritizing quality of care in hospitals is even more crucial. There were only five hospitals in the study areas, but these accounted for over 60% of the facility-based deliveries and nearly 50% of all early neonatal deaths. With hospitals in these districts also serving as the key referral point, this suggests the overall proportion of newborn admissions they received could be much higher. This implies that increasing the quality of hospital-based deliveries alone will serve the majority of facility-based deliveries. This should then be followed by efforts to equip clinics with basic facilities to manage birth asphyxia.

3. Increasing the quality of care in hospitals will require equipping them with essential instruments (such as bag and mask, oxygen apparatus and incubator), medications (including antibiotics, dexamethasone and surfactant), and providing maternity care providers with the skills and resources to manage severe asphyxia and prematurity. Workshops to train maternity care providers in essential newborn care, for example Helping Babies Breathe (252, 253), are important and these should be expanded to increase coverage, but there should be ongoing refresher training and effective monitoring to ensure that maternity care providers maintain

their skills. It is suggested that this should begin with building the capacity of maternity care providers in hospitals. Then the hospitals could serve as a training facility and midwives and doctors in hospitals as resource persons to train maternity care providers in community clinics across the districts.

4. Providing equipment and drugs to improve quality of care in hospitals is the responsibility of the Ministry of Health and a proportion of the ministry's budget should be allocated to improving quality of care. The relationship between health and wealth is well established and governments which are interested in building their economies ought to see quality health as foundation to national development. For example, promoting children's health also reduces the time parents take off to care for sick babies, or mourn their loss. Hospitals should also prioritize quality improvement strategies and consider funding such interventions with alternative measures, for example internally generated funds and through partnerships with non-governmental organisations.

5. Regulatory bodies for clinicians in Ghana, including the Nurses and Midwifery Council and the Medical and Dental Council can encourage its members to seek relevant training in newborn care by awarding credit points for such training, and counting these towards the minimum credit points required for the annual renewal of professional licenses. Since January 2017, the Nursing and Midwifery Council (NMC) of Ghana has introduced a Continuing Professional Development (CPD) plan that requires nurses and midwives to accumulate a number of CPD points in order to have their professional licenses renewed. CPD points may be earned by attending a seminar, workshop, publishing professional articles or books, teaching or lecturing, among others and the NMC has partnered with some organisations which organise seminars and workshops for CPD points. It is recommended that the NMC, for example, encourages midwives to demonstrate skills or training in essential newborn care as an essential requirement for having their licenses renewed. This will ensure that all midwives would have attended at least one refresher course on

essential newborn care each year by which time their licenses are due for renewal.

6. Hospital managers should also make neonatal death a subject of an inquiry as it is in the UK, to ascertain the sequence of events that led to the death of the newborn, and identify ways in which it could have been prevented.

7. Neonatal deaths due to infections could be reduced by decreasing the number of home births and by early recognition and more effective treatment of infections which subsequently develop at home. These can only be realistically achieved if a higher proportion of maternal and neonatal care takes place in community clinics by skilled care providers with a reduction of births at home. These are in line with the targets of the Ghana Ministry of Health (38) and the success of the CHPS programme in the Navrongo HDSS is a good case study (62-64). It is recommended that this is implemented in other regions.

8. Increasing the number of CHPS facilities across Ghana is fundamental to increasing access to skilled care at the community level, promoting universal health coverage, and improving the referral systems. This is clearly a long-term goal requiring significant capital investment (estimated at US$243 million) and the political will to improve the health care infrastructure. The latter seems to be available in Ghana with the government establishing a taskforce to develop a revised CHPS policy, implementation guidelines and a road map. What is then needed most, as reiterated by the taskforce, is funding, and multiple streams of raising funds must be considered.

   First, government must commit a proportion of its budget to constructing new CHPS zones. The ex-president of Ghana and the Executive showed leadership when he committed a tithe of his annual salary to constructing 2 CHPS centres per year. This is admirable, however, it is insufficient and at this rate would take over a century to construct the nearly 4,500 CHPS facilities required across the country. Government must, therefore, call on other development partners including the World Bank, USAID, WHO, JICA among others to help fund the needed CHPS facilities. There is also the need for continued advocacy to encourage other NGOs, local assemblies, and local industries to support community and government efforts. At the same time the many health facility projects (totalling about 4,000 bed capacity) abandoned at various stages of completion but should be resumed.

In the short term, midwives could be posted to deprived areas and provided with basic supplies and logistics to provide antenatal services, manage uncomplicated pregnancies at the community level and neonatal infections at the community level and offer postnatal services. Such policies should be complemented with effective referral systems and effective transportation services that allow complications to be identified early at the community level and transferred to the nearest hospital. Such a systems approach that utilises the available human and capital resources at the hospital, clinic and community level to implement neonatal health strategies can be both effective and sustainable (30).

Because of their level of influence at the community level, TBAs should be involved in delivering maternity care in these deprived communities. Their roles should, however, be limited to encouraging mothers to seek facility births (at an incentive), providing auxiliary help to the professional midwife and supporting home visits. They should, however, be discouraged from conducting deliveries on their own or training other people to do same. It is anticipated that in the early years, there may be challenges to such partnerships, and arrangements should be made to diffuse possible power struggles. It is anticipated that the success recorded in the Upper East region regarding the cessation of home births could be replicated across the country.

8.6.2 Implications for practice

1. Programmes to encourage positive healthcare seeking behaviour and appropriate newborn practices among mothers will include addressing cultural beliefs and myths surrounding neonatal illnesses and educating

the community on the benefits of health facility delivery and early treatment for neonatal illnesses. Target audiences should include mothers, their spouses, other relatives, and relevant communities including churches and mosques. Such programmes should be initiated and driven by the Ghana health service/ Ministry of Health, but involve significant community leaders, religious leaders, key informants, volunteers or other relevant community groups who would be play critical role in organising their communities for such interventions. At the beginning, a community-wide education programme, such as mass campaigns, will raise the average community awareness and educate men who are significant decision makers in newborn care. Community health workers can reinforce learning during routine home to home visits. With over 90% of Ghanaian pregnant women attending ANC, midwives can seize the opportunity to educate, encourage or discuss with mothers on the need for facility delivery and seeking early treatment for newborn illnesses.

2. ANC education should also include education on early signs of labour and use of a birthing plan to encourage and support mothers to deliver with a skilled professional. Mothers should be allowed to ask any questions or raise concerns they may have regarding being delivered in a health facility, or barriers to seeking care in a health facility or practising appropriate neonatal care and these should be addressed accordingly. Women who have no means to access a hospital or clinic should be given an option to be delivered at home by a skilled professional. Appropriate structures or arrangements should be put in place to facilitate skilled home births. Where possible, mothers should be encouraged to attend ANC clinics with significant others who will help in caring for newborns in the postpartum period. It is also within the remit of midwives to liaise with the community health nurses responsible for the woman's community to visit pregnant women in their homes to reinforce antenatal education and asses the wellbeing of the mother and child. As one TBA eloquently puts it:

"In most homes, they do feel lazy to go to the nearest clinic to listen to these talks or listen to counselling. So if our health providers, like our nurses who have been trained to counsel or educate them on these hazards [speaking of malaria] *would make themselves a little bit easy* [come down to the woman's level] *and would like to be visiting the villages or homes, compound by compound, helping them to understand these hazards and others, I think it's one of the best methods that can help"* (TBA G26 14).

3. Postnatal education for mothers should include care of the umbilical cord and bathing practices and this should be followed up with home visits especially in the early neonatal period. All these interventions will, however, profit little if mothers do not feel accepted in the health facilities. Clinicians will benefit greatly from some training in communication and management of women in labour to improve their relationship with women.

4. Autonomy is foundation of decision making- including choices about place of birth, mode of delivery and consequently outcome- and an important way to make childbirth safer for mothers and babies. The consequences of a lack of maternal autonomy is therefore detrimental to newborn health. This thesis showed that maternal autonomy was influenced by spouses, religious leaders and family relations. Three levels of increasing mothers' autonomy are suggested - national, community and household levels;

    i. At the health facility level, midwives are encouraged to involve the woman's significant others- including husbands and in-laws- in antenatal education in order to dispel any cultural or religious beliefs against skilled birth. Women may be incentivised to persuade these significant others to accompany them to antenatal clinic by offering free additional service, 'fast track service' or birthing items such as cot sheet. Husbands who follow their wives to antenatal could also be used as models or examples to encourage others to follow.

ii. At the household level, community health nurses should aim at including husbands or household heads during home visits to the pregnant woman. In order to reach other women who may not be willing to seek skilled service, previous service users could be asked to share their experiences and the benefits of facility births with their colleagues at a ‘pregnancy school’ to motivate them to seek skilled services.

iii. At the community level, durbars and public education initiatives that advocates for skilled maternity care should be promoted. Speakers should include key community leaders, religious leaders, health workers, mothers and husbands.

iv. At the national level, the NHIS should be strengthened to remove any financial and access barriers to seeking skilled care. As already is the policy, it is encouraged that all pregnant women should be registered on the scheme at no cost. Maternity care providers should also be educated not to charge unofficial fees which discourages many women from seeking care.

Safeguarding policies which promote women empowerment and women’s rights should also be instituted to prevent them from being abused or denied skilled services by their significant others. This will also require inter-sectoral collaboration including the Domestic Violence and Violence Support Unit of the Ghana Police Service to prosecute anyone who prevents a woman from seeking health services. Healthcare providers should also be trained to identify possible risks to women and take appropriate action. Women should also have an opportunity to confide in health care providers or safe avenues to report any hinderances to seeking skilled care.

These recommendations are based on findings from this thesis which suggested that factors limiting maternal autonomy hinder skilled care. It should be warned, however, that a woman's autonomy is not restricted to those of her household only. Where a woman has the necessary knowledge and capacity to make decisions regarding childbirth and yet decides contrary to what the healthcare provider believes may be in the woman's interest, her decision should be respected, valued and supported.

As previously acknowledged, some of these reccommendations, for example constructing CHPS facilities although critical, will require substantial additional funding and time. Yet there are others, for example involving women's spouses in antenatal clinics, would not involve so much costs to government. Given the resource challenge Ghana faces, it is suggested that an affordability model could be applied to implementing these suggestions- where responsible organisations implements what is doable in the short term, while implementing other more involving ones in the long term.

8.6.3 Implications for research

1. It is strongly recommended that the HRCs which manage these HDSS conduct regular quality assurance checks to ascertain and ensure that data collected are complete and accurate. This will involve strengthening the community key informant system in order to pick up key events including death as soon as they occur and possibly increasing the number of regular community visits. The HRCs in Ghana should also revise their data collection tools to include other variables such as APGAR score, mode of delivery, presentation, birthweight, and maternal conditions. The data collection instruments used in the three HDSS should also be standardised to allow for regional comparisons. There is a need to code the remaining VPM forms in the various HDSS to understand current trends in NMR, cause of death, and site of death. This will be particularly useful in the Navrongo HDSS where the ban on home births will allow a natural experiment of the effect of the ban on neonatal mortality. In the future, there should be attempts at linking the HDSS data with hospital records to collect information on morbidity, health care seeking behaviour as well as having information validated by medical personnel- the methods

employed in collecting data for the Scottish Morbidity Records system provides an ideal example.

Implementing these will certainly require financial investment and there is a legitimate business case to be made: a) the HDSS serves as a good resource for investigating health in sub-Saharan Africa b) the increased quality of data will increase its usefulness thus attracting more researchers c) the HDSS serves as a centre for training future health researchers. Alternate funding streams for sustaining the HDSS could also be considered: a) the HRC should consider opening itself up as a hub for training epidemiologists where trainees pay a fee; b) future grants applications should include a budget for data management; or c) as in Scotland, researchers who wish to use the HDSS could be required to make a contribution, in exchange for technical support from the HRC.

2. Future studies should also consider community-based interventions which can be tested to improve neonatal health in Ghana. For example;

   i. Will training mid-level health care providers, including community nurses and midwives, in essential neonatal care improve accessibility to skilled services at the community level and will this influence NMR?

   ii. Will a community-led health education programme improve health seeking behaviour in a rural Ghanaian setting?

   iii. Will interventions which promote maternal autonomy increase the proportion of skilled birth attendants or healthcare seeking behaviour, and will this translate into a reduction in NMR?

8.7 Lessons learned

When it became obvious that a single data source was insufficient to answer my research questions, and that I needed to consider a “mixed methods study”, I greeted it with some “mixed feelings”. I was concerned about adding a qualitative component because it wasn’t an area in which I had much experience, save the basic understanding from my MPH degree. With hindsight, I acknowledge that the qualitative journey has been an interesting one. I have had to challenge myself to do a lot of independent reading as well as taking modules in qualitative research methods. It was time-consuming as I had to do these in addition to taking classes in statistics. Now, I am very happy that I can comfortably engage with both qualitative and quantitative data. I believe these complementary skills will be helpful in my research career.

I have also gained valuable project management skills while organising and conducting the field study. I conducted primary research in three research sites in Ghana and this involved a Ghana Health Service ethics application, questionnaire design and budgeting and liaising with directors of the health research centres and directors of health services. I also attended many managerial meetings while negotiating with directors to share their data. I learned that personal visits to conduct face-to-face meetings or even informal engagements with stakeholders could be more productive than exchanging torrents of emails or through the drafting of formal “agreements”.

The ultimate goal in epidemiology is to find out *what* causes or cures a health phenomenon. This often involves complex analyses of large epidemiological data from cohort studies or clinical trials. The enthusiastic epidemiologist, therefore, risks the temptation of losing sight of *who* the research is really about. During my research, I interacted with maternity care providers, health managers and local women. I listened to stories of how local women conducted deliveries, their understanding of the causes of disease and the challenges they faced. These stories and interactions helped me put my research into a proper perspective. As I analysed the quantitative data, 595 neonatal deaths or an NMR of 12 per 1,000 meant more to me than mere statistics: I could put faces behind the numbers. My next challenge is how to help these communities to reduce the NMR.

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Appendices

Appendix 1: Approvals from Ghana

Appendix 1.1: Ethics approval from Navrongo HDSS

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

My Ref.
App/NeonatalMort/06/2015
Your Ref:

GHANA HEALTH SERVICE
GHS
Your Health, Our Concern

Navrongo Health Research Centre
Institutional Review Board
Ghana Health Service
P. O. Box 114
Navrongo, Ghana
Tel/Fax: +233-3821-22348
Email: irb@navrongo-hrc.org

10th June, 2015

Mr. Shadrach Dare
Institute of Health and Wellbeing
University of Glasgow
1 Lilybank Gardens
G12 8RZ, Glasgow, UK

APPROVAL ID: NHRCIRB201

Dear Mr. Dare,

Approval of study title ***A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of deaths and risk factors***

Following your satisfactory address of the concerns raised by the Navrongo Health Research Centre Institutional Review Board (NHRCIRB) during its Board review of the above-mentioned protocol, the Board is pleased to grant you approval.

The following documents were reviewed;

- Completed New protocol submission forms
- Study protocol version 2.0 dated 28/05/2015
- Summary of the Protocol
- Interview guides
- Questionnaire
- Consent forms – English
- Curriculum Vitae of Investigators

Please note that any amendment to the approved document must receive prior NHRCIRB approval before implementation. You are requested to submit a final report of your study to the NHRCIRB and the end of your project.

You are also to note that this approval expires on 9th June, 2016. If your project is not completed by then, you will need to seek an extension of approval.

The Board wishes you all the best in the rest of the study.

Sincerely,

Dr. (Mrs) Nana Akosua Ansah
(Vice Chair, NHRCIRB)

Cc: Director, NHRC

Appendix 1.2: Ethics approval from Kintampo HDSS

Kintampo Health Research Centre (KHRC) Institutional Ethics Committee (IEC)
P.O Box 200
Kintampo, B/A
Ghana, West Africa
Tel: +233(3520)92037 (Ext 117)
E-mail: fred.kanyoke@kintampo-hrc.org

FULL ETHICAL APPROVAL CERTIFICATE

Shadrach Dare
PhD student
Institute of Health and Wellbeing,
1 Lilybank Gardens
University of Glasgow. G12 8RZ, UK

Date: 12th June 2015

Study File Number: 2015-9

Title of study: A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of death, and risk factors.

Principal Investigator(s): Shadrach Dare

Supervisor(s): Dr. Daniel F. Mackay, Professor Laurence Gruer, Professor Jill P. Pell

Type of Review: Expedited Review

Approval Date: 9th June, 2015

Expiration Date: 9th June, 2016

1. The Kintampo Health Research Centre Institutional Ethics Committee (IEC) is constituted and operates in conformance with requirements of 45 CFR 46, 21 CFR 50, 21 CFR 56 and section 3 of the International Council on Harmonization Guidelines. The OHRP Federal wide Assurance number for the committee is 00011103; the IRB registration number is 0004854.

2. The above study in title was reviewed by the IEC on 2nd June, 2015.

3. A full ethical approval was granted for implementation of the study on 9th June 2015 after a revised protocol was submitted and approved by the Committee.

4. The following documents were reviewed and approved;
   - 4.1 A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of death, and risk factors
   - 4.2 Information sheet and consent form
   - 4.3 Interview Guide
   - 4.4 Study Budget
   - 4.5 Curriculum Vitae of PI and Supervisors

File number: 2015-9

THE CHAIRMAN, KINTAMPO
HEALTH RESEARCH CENTRE
INSTITUTIONAL ETHICS
COMMITTEE

Kintampo Health Research Centre (KHRC) Institutional Ethics Committee (IEC)
P.O Box 200
Kintampo, B/A
Ghana, West Africa
Tel: +233(3520)92037 (Ext 117)
E-mail: fred.kanyoke@kintampo-hrc.org

5. During study implementation, the IEC must be informed within 72 hours by the principal investigator (PI) of learning of any (a) unexpected, serious, study related adverse events; (b) disclosed adverse events, or (c) unanticipated problems with the study which may pose risk to study participants or others.

6. All safety monitory reports, including DSMB summaries and reports, must be submitted to the IEC as soon as they become available to PI(s).

7. Changes or modifications to this research activity must be submitted and approved by the IEC before they are implemented.

8. PI(s) would be required to submit application for renewal of this approval certificate (if necessary) plus a progress report.

9. PI(s) is required to notify the IEC of study completion (end of data collection/last follow-up) or early termination of the research project.

10. Submit final report of the study three months after approval certificate expires (study closure)

11. Before conduct of the study, submit original/final copy of your informed consent form for **authentication stamp** before making photocopies for your consent process.

12. Regulated study records, including IEC approvals and signed consent forms, must be securely maintained by PI(s) and available for audits for three years after the study is closed with the IEC.

Sincerely,

....

Charlotte Tawiah Agyemang
Vice Chair
Institutional Ethics Committee
Kintampo Health Research Centre

THE CHAIRMAN KINTAMPO
HEALTH RESEARCH CENTRE
INSTITUTIONAL ETHICS
COMMITTEE

File number: 2015-9

Page 2 of 2

Appendix 1.3: Ethics approval from Dodowa HDSS

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

Dodowa Health Research Centre
Ghana Health Service
P. O. Box DD1
Dodowa

Tel: +233-50-1336188
Email: IRBdodowa@gmail.com

My Ref. : DHRC/1RB/15/03
Your Ref. No.

12th August 2015

Shadrach Dare
University of Glasgow
Institute of Health and Wellbeing
United Kingdom

RE: STUDY NO.DHRC/050415 **AT: DHRC-FULL REVIEW**

Dear Sir,

PROTOCOL TITLE: A COMPARATIVE STUDY OF NEONATAL MORTALITY IN GHANA AND SCOTLAND: TRENDS, DISTRIBUTION, CAUSES OF DEATH, AND RISK FACTORS.

This is to inform you that the protocol number DHRCIRB/050415, dated 2nd March, 2015 was presented to the DHRC Institutional Review Board for a subsequent review The study is recommended for ethical approval after modification. Please find below comments to be addressed. A final certificate will be issued upon receipt of a response addressing the issues raised.

1.0 Ethical issues of concern with suggestions for modification:

1.1 The Informed Consent form has no title; the qualitative study is among health workers, hence must be indicated on the form. This also applies to the interview guide.

Yours sincerely,

Irene Honam Tsey
(IRB Administrator)

Appendix 1.4: Permission letter from Upper East Regional Health Directorate

OUR CORE VALUES
- *People-Centred*
- *Professionalism*
- *Team work*
- *Innovation*
- *Discipline*
- *Integrity*

My Ref No. GHS/UE/
Your Ref. No

GHANA HEALTH SERVICE
GHS
Your Health • Our Concern

Regional Health Directorate
Ghana Health Services
Private Mail Bag
Bolgatanga, UER
GHANA.

28th July, 2015

Tel: (03820) 22335
Fax:038202-24390
E-mail ghs-uer@4u.com.gh

THE MUN/DISTRICT DIRECTOR OF HEALTH SERVICES:
KASSENA NANKANA MUNICIPAL, NAVRONGO
KASSENA NANKANA WEST, PAGA

RE: PERMISSION TO INTERVIEW DOCTORS, MIDWIVES AND TRADITIONAL BIRTH ATTENDANTS IN THEKASSENA NANKANA EAST AND WEST DISTRICTS

This is to introduce to you Mr. Shadrach Dare a PhD Student who has my approval to interview Doctors, Midwives and Traditional Birth Attendants in your BMCs on his research work.

Find attached copies of letters from the University of Glasgow to that effect.

Kindly accord him your support and co-operation in this regard.

Thank you.

PETER BOATENG
DEPUTY DIRECTOR – ADMINISTRATION
For: REGIONAL DIRECTOR OF HEALTH SERVICES (UER)

cc: Mr. Shadrach Dare

Appendix 1.5: Permission letter from Kintampo South District Health Directorate

University of Glasgow

Institute of Health & Wellbeing

Athena SWAN Bronze Award

RECEIVED DATE 21/08/?? KPO. SOUTH DIST.

23rd June 2015

The Director of Health Services
Kintampo South Health Directorate
Kintampo, Ghana.

PERMISSION TO INTERVIEW DOCTORS, MIDWIVES AND TRADITIONAL BIRTH ATTENDANTS

I am Mr Shadrach Dare, a Registered General Nurse with the Nurses and Midwives Council, Ghana and a current PhD Research student in the Institute of Health and Wellbeing, University of Glasgow, UK. The title of my PhD is: A comparativ study of neonatal mortality in Ghana and Scotland: rates, trends, distribution, risk factors and causes of death.

The research is in collaboration with the Navrongo, Dodowa and Kintampo Health Research Centres in Ghana and will be carried out in the Navrongo, Kintampo and Dodowa surveillance areas respectively. The research has been approved by the Institutional Review Committees in the Navrongo and Kintampo Health Research Centres and is currently being considered by the Scientific Review Committee at the Dodowa Health Research Centre. The research involves analysis of computerised data provided by the research centres and interviews with doctors, midwives and traditional birth attendants in the study settings.

I humbly request your permission to interview up to five doctors, ten midwives and five traditional birth attendants in the Kintampo South district. The interviews are a crucial component of the research because they will provide insights into the contextual factors underlying neonatal mortality in the study areas. I hope to conduct the interviews from October to December 2015.

The research findings will be included in a PhD thesis submitted to the University of Glasgow. A link to the electronic copy of the thesis will be made available to the Kintampo South health directorate and a summary report will be submitted to the health directorate.

As a nurse and a researcher, I have the required understanding and training regarding administering questionnaires. In addition, I have an obligation to adhere to the ethical standards contained in the ethics approval certificates. Kindly find attached the ethics approval certificates, the questionnaire and my CV for your consideration.

I very much hope you will be able to authorise this request and look forward to hearing from you in the near future.

Acknowledged. Please give him the needed assistance. Thank you

D. D. H. S
KINTAMPO SOUTH DISTRICT
HEALTH DIRECTORATE
JEMA B/A

?/?/2015

The University of Glasgow, charity number SC004401

The Queen's Anniversary Prizes

Appendix 1.6: Permission letter from Kintampo North Health Directorate

OUR CORE VALUES
1. *PEOPLE-CENTRED*
2 *PROFESSIONALISM*
3. *TEAM WORK*
4 *INNOVATION*
5. *DISCIPLINE*
6. *INTEGRITY*

My Ref No. MHD/KN/
Your Ref No

GHANA HEALTH SERVICE
GHS
Your Health - Our Concern

MUNICIPAL HEALTH DIECTORATE
GHANA HEALTH SERVICES
P. O. BOX 2
KINTAMPO-NORTH
Tele/Fax :03520-36019

23rd July, 2014

LETTER OF INTRODUCTION

I am requesting your support to enable Mr. Shadrach Dare, a PhD student in the Department of Public Health, Institute of Health and Wellbeing, University of Glasgow, UK, work on his Research topic'' A comparative study of neonatal mortality in Ghana and Scotland: rates, trends, distribution, risk factors and causes of death in the Kintampo Municipality.

I wish to inform you that kindly offer him necessary support and assistance to enable him successfully complete the research work.

Thank you.

MS ALICE A. VORLETO
AG.MUNICIPAL DIRECTOR OF HEALTH SERVICES

ALL FACILITY IN-CHARGES
KINTAMPO-NORTH MUNICIPALITY

MUNICIPAL DIRECTOR
GHANA HEALTH SERVICE
KINTAMPO NORTH
KINTAMPO B/A

Appendix 1.7: Permission letter from Greater Accra Regional Health Directorate

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

My Ref. No.

Your Ref. No.

GHANA HEALTH SERVICE
Your Health - Our Concern

GHANA HEALTH SERVICE
REGIONAL HEALTH DIRECTORATE
GREATER ACCRA
P. O. BOX 184
ACCRA

Tel: +233-0302-234225/226203

E-mail:lavanotoo@yahoo.com
linda.vanotoo@ghsmail.org

13 July 2015

THE DISTRICT DIRECTOR OF HEALTH SERVICES
SHAI OSUDOKU DISTRICT HEALTH DIRECTORATE
DODOWA

RE: PERMISSION TO INTERVIEW DOCTORS, MIDWIVES AND TRADITIONAL BIRTH ATTENDANTS

Permission has been given by the Greater Accra Regional Health Directorate to enable Mr. Shadrach Dare, a PhD student from the University of Glasgow, UK, Institute of Health and Wellbeing to interview some Doctors, Midwives and Traditional Birth Attendants on the topic: ***"A Comparative Study of Neonatal Mortality in Ghana and Scotland: Rates, Trend, Distribution, Risk Factors and Cause of Death"*** in your district as per attached.

Kindly accord him with the needed assistance to enable him to conduct the interview successfully.

Thank you.

DR. LINDA A. VANOTOO
REGIONAL DIRECTOR OF HEALTH SERVICES
GREATER ACCRA

cc: Mr. Shadrach Dare
PhD Student
Commonwealth Scholar & Joint Co-ordinator for Scotland Regional Network

Appendix 2.0 : Approvals from Scotland

Appendix 2.1: Certificate of information governance course

UK Data Service

CERTIFICATE OF MEMBERSHIP

This is to certify that

Shadrach Dare

University of Glasgow

has completed induction training and is now a member of the Secure Lab community of trusted researchers

15 December 2014

Richard Welpton
Secure Lab Manager

Appendix 2.2: Ethics approval from Scotland

Information Services Division
Area 151A
Gyle Square
1 South Gyle Crescent
EDINBURGH
EH12 9EB
Telephone 0131 275 6000
Fax 0131 275 7606
www.isdscotland.org

NHS National Services Scotland

Mr S Dare
PhD student
University of Glasgow

Date 17 June 2015
Your Ref
Our Ref PAC 82/14
Enquiries to Janet Murray
Extension 6954
Direct Line 0131 275 6954
Email janet.murray1@nhs.net

Dear Mr Dare

A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of death, and risk factors

Your PAC Application has undergone NSS proportionate governance review and has been approved.

Conditions applied: The training undertaken by the principle investigator is not appropriate for IG training. Please ensure that they complete approved IG training such as the MRC Data and Confidentiality On-line training.'

Time period: As specified
Points highlighted: None

The approval is for a period of 5 years from the date of this letter. Any change to the terms of your application, including changes in data user(s), additional data fields or extension of the time period approved must be requested through Susan Kerr, PAC Administrator on 0131 275 6445 or nss.pac@nhs.net.

Please note that the access to data facilitated by this approval is subject to the satisfactory completion of approved information governance training, which must be updated every 3 years.

Please note that the following details about your application will be published under the following headings on the PAC website at http://www.nhsnss.org/pages/corporate/pac_meetings_and_decision_making.php later this year:

No	Title	Type	Summary	Date sent to PAC	PAC Responses	NSS Decision	Date Completed

POSITIVE ABOUT DISABLED PEOPLE

Chair Professor Elizabeth Ireland
Chief Executive Ian Crichton
Director Phillip Couser

NHS National Services Scotland is the common name of the Common Services Agency for the Scottish Health Service.

In order to progress your request please contact the eDRIS team on telephone 0131 275 7333 or email nss.eDRIS@nhs.net.

Yours sincerely

JG Murray

Dr Janet Murray
Consultant in Public Health Medicine

cc eDRIS

Appendix 3.0 : Data collection tools

Appendix 3.1: Information sheet

University of Glasgow | Institute of Health & Wellbeing

Title: A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of death, and risk factors.

Why is this research being done?
This research is about babies who have died up to 28 days after they are born. We want to learn more about why they died in Ghana. It is hoped it will help to prevent the deaths of new-born babies in the future. The research is being done by the University of Glasgow, UK together with the Navrongo, Kintampo and Dodowa Health Research Centres in Ghana.

Why am I being asked to take part?
We would like to speak to you because you provide maternity services for women in this district. We hope you can tell us about how you help women deliver their babies.

What is involved and how long will it take?
The interview will last about 60-90 minutes. There is no right or wrong answers. Our voices will be recorded to make sure that no information is lost and to reduce the need for writing during the interview.

Do I have to take part?
You should only take part if you want to.

What are the risks or benefits for participating in this research?
We don't think the questions will make you feel uncomfortable but you can refuse to answer any question if you wish.
The information you provide us with will help us prevent the deaths of new-born babies in the future

What happens if I change my mind?
You can stop the interview and say you do not want to be part of the study at any time.

How will the information I provide be used?

The questionnaires and tape recording will only be used by the researchers to write reports to help people learn more about why some babies die in Ghana. Whenever they write or speak about the interviews, they will not say anything that would show the information came from you. The information you give will not be used for any other purpose.

How do I find additional information?

You can ask any questions you like during the interview. If you have questions after the interview, you can contact the main researcher, Mr Shadrach Dare at (+233) 0246595053 OR +44 141 330 4554, for him to answer.

If you are in Kintampo and you have questions about your rights as a research participant, please contact Rev. Dr. Joe Eyison, Chairman of Kintampo Health Research Centre Institutional Ethics Committee at (+233) 0242264659

Thank you for your help

Appendix 3.2: Interview consent form

University of Glasgow | Institute of Health & Wellbeing

Interview consent form

Title of Project:	A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of death, and risk factors
Name of Researcher:	Mr Shadrach Dare
Address:	Institute of Health and Wellbeing, University of Glasgow, UK. 1 Lilybank Gardens, Glasgow, G12 8RZ
Collaborators:	Kintampo Health Research Centre, Kintampo Dodowa Health Research Centre, Dodowa Navrongo Health Research Centre, Navrongo
Funding:	Commonwealth Scholarship Commission in the UK

Please read the statements below and write down your initial in each box if you agree and sign at the bottom

1. I confirm that I have read the information sheet or the information sheet has been read to me and I understand what it says. I know I can ask any questions about it. ☐

2. I understand that I do not have to take part if I do not wish to ☐

3. I understand I can drop out of the study at any time if I wish to ☐

4. I understand that all the information I provide will be kept private, and in anything written or spoken about the project it will not be possible for anyone to know what I said. ☐

5. I give permission for this interview to be sound recorded ☐

6. I give permission for the information I provide in this study be used in reports, publications and presentations ☐

7. I know who to contact if I have any concerns in the future regarding this research ☐

8. I agree to take part in this interview for the research project ☐

....	....	....
Name of interviewee	Date	Signature/ thumbprint
....	....	....
Name of witness	Date	Signature
....	....	....
Name of researcher	Date	Signature

Appendix 3.3: Questionnaire

Questionnaire

A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of deaths and risk factors

Study ID | | | | | | |

Background Characteristics

1. To which of the following groups do you belong?
- ☐ Doctor in a hospital
- ☐ professional midwife (in a hospital)
- ☐ professional midwife (in the community- CHPS)
- ☐ traditional birth attendant (TBA)
- ☐ Other (please specify. Eg. Spiritualist): ……………………………………………

If TBA, from where did you learn the skill to deliver
……………………………………

If TBA, where do you provide your services
- ☐ You visit the homes of the pregnant women to conduct deliveries
- ☐ Women come here to be delivered
- ☐ Other (Please specify): ……………………………………………………….

2. Which community and region do you work in?

(Please state community):……………………………….
- ☐ Greater Accra region
- ☐ Brong-Ahafo region
- ☐ Upper East region

3. For how many years have you practised as an obstetrics doctor, midwife or birth attendant? …………….. years

4. For how many years have you practised in this district? ………………………. years

Birth Practices: Background

5. Which of the following services do you provide?
- ☐ spontaneous vaginal delivery
- ☐ assisted vaginal delivery e.g. forceps
- ☐ caesarian section
- ☐ care of sick pregnant women
- ☐ care of sick babies
- ☐ Others (please state): …………………………………..

6. About how many deliveries do you do in a typical week?

7. How far is it from where you deliver babies to the nearest hospital?

   a. By car …………………..

      If by car, how much does it cost ………………

      If by car, how easy it is to get a car at odd hours (Eg. At night)
      - ☐ <30 minutes
      - ☐ 30- 1 hour
      - ☐ 1- 3 hours
      - ☐ > 3 hours
      - ☐ Once a day
      - ☐ > twice a week
      - ☐ Once a week

   b. By walking …………………………….

8. What types of pregnancies do you deliver? (please tick all which apply)

- ☐ First pregnancies
- ☐ Twins or triplets
- ☐ Where the woman has another serious medical problem (For example pre-eclampsia/ High blood pressure)
- ☐ Women aged less than 20 years
- ☐ Women aged more than 35 years
- ☐ Pregnancy which is less than 37 weeks old
- ☐ Pregnancy with less than 18 months from a previous birth
- ☐ Others (please state): ……………………………….

Birth Practices: Infections

9. Which of these instruments and equipment do you use in conducting a delivery (please tick all which apply)

- ☐ Fetoscope
- ☐ Delivery bed
- ☐ Gloves
- ☐ Vital tray (thermometer, blood pressure apparatus/ sphygmanometer)
- ☐ Forceps for delivery
- ☐ Artery forceps
- ☐ Scissors
- ☐ Ventouse for vacuum extraction
- ☐ Blade
- ☐ Cord clamps / cord

- ☐ Weighing scale
- ☐ Suction pump
- ☐ Resuscitation/ breathing apparatus
- ☐ Incubator
- ☐ Cotton swabs
- ☐ Bulb syringe
- ☐ Oxygen
- ☐ Cleansing solution
- ☐ Ambulance

Others (please list)

- ☐ ……………………………………...
- ☐ …………………………………………
- ☐ …………………………………………

10. Which of the things on the above are sterile or new before use?

11. If a pregnant woman comes to you with contractions, which of the following assessments do you perform to assess the health of the baby
    i. before delivery/ during labour
        - ☐ vaginal examination
        - ☐ Fetal heart rate
        - ☐ Palpation
        - ☐ Observation
        - ☐ Other (Please state) …………………………………….

    j. After delivery
        - ☐ Suckling
        - ☐ Crying
        - ☐ Movement
        - ☐ Breathing
        - ☐ Colour
        - ☐ Pulse
        - ☐ Grimace
        - ☐ Other (Please state) ……………………………….

12. Describe how you would perform a vaginal examination on a mother to access the descent or health of the baby

13. Which of the following practices do you follow to prevent infection during delivery
    - ☐ Use sterile/ new instruments
    - ☐ Wash hands
    - ☐ Wear protective clothing Eg. apron
    - ☐ Wear sterile gloves
    - ☐ Using cleaning solution before examination
    - ☐ Ensure a clean environment
    - ☐ Deliver baby unto a clean field
    - ☐ Other (please state): ……………………………………………….

14. Describe how you care for the umbilical cord stump after delivery
    - ☐ Use methylated spirit
    - ☐ Use boiled cooled water
    - ☐ Use shear butter/ cream
    - ☐ Use herbal concoction
    - ☐ Other (please state): ………………………………………………..

15. Describe how you clean the delivery site after the each delivery
16. Describe what you would do if you think that the pregnant woman **in labour** may have some sort of infection e.g. she has a fever or there is pus or foul smelling yellowish discharge from the vagina

    - ☐ High vaginal swab
    - ☐ Give intrapartum antibiotics before delivery
    - ☐ Treat infection after delivery
    - ☐ Expedite delivery with use of oxytocin
    - ☐ Expedite delivery with caesarian section
    - ☐ Blood for inflammatory markers
    - ☐ Continuous monitoring of the baby in utero
    - ☐ Give herbal concoction
    - ☐ Call doctor
    - ☐ Refer to nearest hospital
    - ☐ Other (please specify): ………………………………………………..

17. Do you give a newborn an enema?
    - ☐ Yes
    - ☐ No

    If Yes, what is your reason/ why do you give a newborn enema?..........................

    If Yes, after how many days do you give the newborn his or her first enema? …………….. days

If Yes, what solution do you use for the first enema? (please state) ………………………….

If Yes, where do you get the syringe from (ask if new)

……………………………………………………………………………………..

18. Describe how you would manage a baby if the mother had some sort of infection during labour Eg. She has a fever or there is pus or foul smelling yellowish discharge from the vagina
    - ☐ Observe baby for infection
    - ☐ Give antibiotics
    - ☐ Give herbal concoction/ enema
    - ☐ Refer baby to nearest facility
    - ☐ Inform doctor
    - ☐ Other (Please specify): …………………………..

19. Describe what you will do if a pregnant woman “breaks water” before going into labour (starts having contractions) when
    - **a. She is after 28-36 weeks pregnant**
        - i. How long would you take before you take action?
            - ☐ Expedite delivery when she breaks water
            - ☐ Induction 34- 36 weeks if no labour
            - ☐ Wait for pregnancy to reach 36 weeks before induction
            - ☐ Wait until she goes into labour
            - ☐ Wait until you see signs of infection
            - ☐ Call doctor
            - ☐ Refer to nearest hospital
            - ☐ Other (please specify): ………………………………..
        - j. What actions would you take?
            - ☐ Induction of labour
            - ☐ Caesarean section
            - ☐ Administer steroids
            - ☐ Give prophylactic antibiotics
            - ☐ High vaginal swab
            - ☐ Regular measurement of temperature
            - ☐ Frequent blood checks
            - ☐ Monitor fetal wellbeing
            - ☐ Call doctor
            - ☐ Give herbal concoction
            - ☐ Refer to nearest hospital
            - ☐ Other (Please specify); ……………………………………..

b. She is more than 36 weeks pregnant

i. How long would you take before you take action?
- ☐ Induce labour
- ☐ Monitor until she goes into labour
- ☐ Wait until you see sign of infection
- ☐ Call doctor
- ☐ Refer to nearest hospital
- ☐ Other (please specify): ………………………………..

j. What actions would you take?
- ☐ Induction of labour
- ☐ Caesarean section
- ☐ Administer steroids
- ☐ Give prophylactic antibiotics
- ☐ High vaginal swab
- ☐ Regular measurement of temperature
- ☐ Frequent blood checks
- ☐ Give herbal concoction
- ☐ Call doctor
- ☐ Refer to nearest hospital
- ☐ Other (Please specify): ……………………..……………..

20. Describe what you would do if the baby is ill (for example has fever or too cold, not feeding well, breathing difficulty) when he or she is born.
    i. How would you assess

    j. How would you intervene?

21. i. If a newborn baby, who is less than one month old, was sick, where would be the first place mothers in this community will take him/ her to?
    - ☐ Clinic
    - ☐ Hospital
    - ☐ TBA
    - ☐ Home
    - ☐ Other, (please state)

    ii. Why do you think mothers would do so?

22. How would you care for a newborn that is brought to you sick when he/she is less than one month old?

Birth Practices: Preterm birth

23. When do you check for the weight of a newborn baby after he or she is born?

- ☐ Immediately
- ☐ After a day
- ☐ 2-7 days
- ☐ >7 days
- ☐ Never
- ☐ Other (Please specify): …………………………

Do you check his or her weight by yourself?

- ☐ Yes
- ☐ No

24. Describe how you would define a baby who is "too early" to be born (preterm)

- ☐ <28 weeks
- ☐ 28- 36 weeks
- ☐ 37 weeks and more

25. How would you assess, before delivery, if a baby is "too early" to be born

- ☐ Ask mother for age of pregnancy
- ☐ Assess early booking scan
- ☐ Asses last menstrual period
- ☐ Palpate for size of uterus (womb)
- ☐ Check fundal height
- ☐ Other (Please state): ……………………………….

26. What do you consider to be the normal weight for a newborn baby?

- ☐ <2.5kg
- ☐ 2.5- 4 kg
- ☐ >4 kg
- ☐ Other (please specify)

27. How would you assess if a baby is too small?

- ☐ Use a weighing scale
- ☐ Observation
- ☐ Other (Please state): ………………………..

28. Describe what assessments you would perform on a baby who is born "too early" or preterm

- ☐ Assess suckling reflexes
- ☐ Assess swallowing reflexes
- ☐ Other (Please specify): ………………………………………………….

29. Describe how you would manage a baby who is too small or has low birth weight once s/he is born
    - ☐ Refer to NICU
    - ☐ Check blood sugar
    - ☐ Call doctor
    - ☐ Refer to nearest health facility
    - ☐ Advise the mother
    - ☐ Others (Please specify): ………………………………………

Birth Practices: Birth Asphyxia

30. If a pregnant woman came to you and said she has uterine contractions (or in labour), how would you assess if she is in labour or when she is due?
    - ☐ Time contractions
    - ☐ Do vaginal examination
    - ☐ Observe
    - ☐ Other (Please specify) ……………………………………..

31. If a pregnant woman came to you and said she has uterine contractions (or is in labour)
    i. How many hours would you allow the woman to be in labour before you intervene?
       - ☐ 6- 12 hours
       - ☐ 13- 18 hours
       - ☐ 19-24 hours
       - ☐ >24 hours
       - ☐ Other (please state): ………………………………

    j. What action would you take?
       - ☐ Monitor baby using fetoscope
       - ☐ Give oxytocin (Augmentin)
       - ☐ Caesarean section
       - ☐ Call doctor
       - ☐ Give herbal concoction
       - ☐ Refer to nearest hospital
       - ☐ Other (Please state): ……………………………..

32.
    i. How long would you observe or allow a woman to be fully dilated woman to labour before you take further action? (Please state)

    j. What actions would you take?

       - ☐ Induction of labour
       - ☐ Caesarean section
       - ☐ Administer steroids
       - ☐ Give prophylactic antibiotics
       - ☐ High vaginal swab

- Regular measurement of temperature
- Frequent blood checks
- Give herbal concoction
- Call doctor
- Refer to nearest hospital
- Other (Please specify): ……………………..……………..

33. Describe how you would manage a newborn baby who is not breathing properly or has a bluish skin

34. Describe how you manage a baby who is born with greenish liquor

Place of Delivery

35. Kindly state which of the following services you provide which makes this facility attractive to pregnant women?

- Spiritual support
- We treat diseases in pregnancy
- We offer herbal concoctions throughout pregnancy
- We allow partners/ family presence during delivery
- We offer prenatal care services

  Please specify: ……………………………….

  ……………………………………………………

- We allow mothers to deliver in whichever position they are comfortable with
- We call them on telephone to check up on how they are doing after they leave for the house
- There is no cost for our service
- We visit mothers in the house after delivery
- We go to help the mother take care of the baby after delivery
- Others (please specify): ……………………...……..

....
…………………………………………………………

36. If women have a choice of being delivered in the health facility or by the traditional birth attendant, why do you think they chose you? (You may select more than one response)

- We are the only ones who provide the service nearby
- The mothers have confidence in us
- The family can’t afford to go to the clinic
- The family believe we provide a better service here

- ☐ We offer spiritual support
- ☐ We give them herbal concoctions throughout pregnancy
- ☐ We don't charge them any amount
- ☐ We treat them very well
- ☐ They feel comfortable with us
- ☐ They are much comfortable in the home environment
- ☐ They are free to share anything bothering them with us
- ☐ We are highly recommended
- ☐ We spend much time by the woman in labour
- ☐ We allow mothers to deliver in whichever position they are comfortable with
- ☐ We support them throughout labour

  Please specify………………………………….
- ☐ Others (please state)

  ……………………………………..

  ……………………………………..

  ……………………………………...

37. What reasons do you think hinder women to seek care from you or this facility (please state)?
    - ☐ Distance
    - ☐ Cost
    - ☐ They spend too much time here
    - ☐ They think we are unfriendly
    - ☐ Religious reasons
    - ☐ Accessibility
    - ☐ Facilities
    - ☐ Cultural
    - ☐ Preference
    - ☐ Other (please specify): ………………….

38. How long after birth do you wait before you help the mother to start breast-feeding?
    - ☐ Within 30 minutes
    - ☐ >30 minutes- 1 hour
    - ☐ Within 1 day
    - ☐ 2- 3 days
    - ☐ 4- 7 days
    - ☐ >7 days

39. If a baby does not suck at birth, how long would you leave it before taking action?
    - ☐ 1 hour
    - ☐ 1 day
    - ☐ 2- 3 days
    - ☐ 4- 7 days
    - ☐ >7 days

40. What do you do if the baby isn’t able to breast-feed successfully?

41. What are the main reasons for a baby not being able to breast-feed successfully?

- ☐ Baby doesn’t like breastmilk
- ☐ Complications with the breast Eg. Mastitis/ inverted nipples
- ☐ Poor placement of baby
- ☐ Others (please specify)

…………………………………………………

………………………………………………….

…………………………………………………..

42. Describe how you assess the condition of the baby after birth before she goes home (clinic delivery), or you leave her home (home delivery).

43. On average, how long after delivery is it before mothers go home (facility delivery) or you leave her home (home delivery)?

Facility delivery:…………………………… Home delivery: ………………………

44. Before the mother goes home or you leave her home, what arrangements, if any, do you make to see her again and her child?

45. Before a mother goes home, what arrangements do you make for her to get her child immunized?

46. How do mothers who deliver in this facility access postnatal care?

47. In what situations, would you say to the mother that you think her baby should be seen by someone else and by whom?

i. Before labour

j. After delivery

Hypothermia

48. Describe how you clean/ bath a newborn baby after he or she are born?
    a. If baby was born in less than 9 months

b. If baby was born in at least 9 months

49. How many times in a day on average do you bath a newborn baby?

50. Describe what factors you would consider when selecting the clothing for a newborn baby

51. Do you think it is important to keep baby warm? Please give reason for your response.

Healthcare related factors

52. On a scale of 1 (least proficient) to 5 (most proficient), do you think you have the requisite skills to do the following

	1	**2**	**3**	**4**	**5**
Resuscitate a baby					
Manage a baby with infection					
Manage a preterm baby					
Manage a baby with low birth weight					
Manage an asphyxiated baby					

53. Do you think you have the requisite facilities to manage the following conditions

	Yes	**Yes, but not adequate**	**No**
Resuscitate a baby			
Manage a baby with infection			
Manage a preterm baby			
Manage a baby with low birth weight			
Manage an asphyxiated baby			

54. By what means do you transport babies from this facility to the next?

55. Describe what you would do before you refer the baby to the nearest facility, if the baby is;
    a. Premature

    b. Asphyxiated

    c. Has infection

Cultural Factors

56. Do you know of any cultural or traditional beliefs in your area which influence mothers' decisions about where she will deliver her baby- home delivery or clinic delivery?

57. What are the cultural or traditional beliefs in your area which influence which type of delivery a mother will choose- vaginal delivery, or caesarean section?

58. Do you know any cultural or traditional beliefs in your area which influence how mothers care for their new born babies? Eg. Caring for fontanelles, what makes a baby strong and healthy

59. Are there any other factors or reasons (not covered) that you think make newborn babies more likely to die within the first month of birth?

Do you have any questions to ask?

Thank you very much for your help.

Appendix 3.4: Interview guide

Interview Guide

A comparative study of neonatal mortality in Ghana and Scotland: trends, distribution, causes of deaths and risk factors

1. I would like you to talk me through a memorable delivery of a baby who **was not** breathing properly after birth.
   a. Who was present with you at the delivery?
   b. How was the baby delivered?
   c. Which assessments did you do on the **mother** before delivery? (If not, ask why it wasn't done).
   d. How did you **assess the baby** after birth? (If no assessment done, ask why it wasn't done)
      i. Did you also check **temperature, pulse, respiration and blood pressure**? (If not, why not?)
      ii. Did you check for **oxygenation** and **blood glucose level** of the baby (If not ask why not?).
      iii. Did you take sample for any laboratory investigation? If yes, which ones, If no, why not?
      iv. Is that common for all babies?
   e. How did you **care for the baby**?
      i. Where did you care for the baby?- Is it a specialized unit? Is it an air-conditioned room or is there a fan?
      ii. If baby was resuscitated or given oxygen, could you tell me how you resuscitated the baby? (If you didn't resuscitate the baby, could you tell me why you didn't resuscitate the baby)
      iii. If baby was resuscitated, how did you know the baby had received enough oxygen?
      iv. Which key drugs were given to the baby?
      v. How did you **monitor the progress** of the baby and for how long?
      vi. Have you received any training on resuscitating a baby?
   f. If **referred**, how long after delivery was the baby referred?
      i. What you arrangements did you do before referring the baby to the nearest facility? (If not, why didn't you refer the baby?)

ii. Could you describe how the baby was transported to the next referral site?
iii. Did you accompany the baby to the referral site?

g. Did the baby survive or died?
h. Finally, in your view how could you have managed the baby better?

2. I would like you to talk me through a memorable delivery of a baby who was born **after less than 9 months** of pregnancy.
   a. I would like to ask you some questions about where the delivery was conducted (If not done, ask why)
      i. Where was the delivery conducted?
      ii. Who was with you while delivering the baby?
      iii. How was the baby delivered?
      iv. What arrangements did you make before the birth of the baby?
      v. Is that common practice for all babies who are born in less than 9 months after pregnancy?
   b. Which **assessments** did you do on baby after birth?
      i. Ask as in asphyxiated baby (see above)
      ii. Did you check for the birth weight?
      iii. Did you check if the baby could suck?
   c. I would like you to tell me about the **management** of the baby
      i. How did you **care for the baby**?
      ii. Where did you care for the baby?- Is it a specialized unit? Is it an air-conditioned room or is there a fan?
      iii. How did you keep the baby warm? Did you keep him or her in an incubator? (If not why not)
      iv. How was the baby fed?
      v. How did you monitor the progress of the baby?
      vi. How long did the baby stay in the facility before being sent home or referred?
      vii. Is that common for all babies who are born in less than 9 months after pregnancy?
   d. If baby was referred,
      i. Could you tell me how long after delivery was the baby referred?
      ii. What you arrangements did you do before referring the baby to the nearest facility? (If not, why didn't you refer the baby?)

iii. Could you describe how the baby was transported to the next referral site?

iv. Did you accompany the baby to the referral site?

e. Did the baby survive or die?

f. Finally, in your view, how could you improve on how you cared for the baby?

3. I would like you to tell me about a baby who had an infection following delivery
    a. What do you remember about the mother of the sick baby?
    b. How did you know the baby was sick?
    c. What was the diagnosis and how did you diagnose that?
    d. How did you manage the baby?
    e. Was the baby transferred to any other facility?
    f. Which drugs did you give the baby? Ask about any local herbs given
    g. How was the mother delivered?
    h. Did the mother receive any medications during delivery?
    i. What was the outcome of your care for the baby? Did the baby survive or die?
    j. If the baby died, after how many days did the baby die?
    k. How differently will you manage another case of a baby who is sick in the future?
4. I would like us to talk about how you follow up on patients;
    i. What arrangements do you make to see the child who is delivered in this facility?
    ii. What alternate arrangements do you make if you do not hear from the mothers? (If no follow up, ask why)
5. I would like you to tell me about the baby who died in this facility
    a. Can you please tell me what happened when the baby was brought in
    b. What was the condition of the mother?
    c. What was the condition of the baby
    d. What did you do for the baby when he or she was brought in?
    e. Was the baby transferred to any facility?

NB: Ask follow up questions as the need arise. These questions are only meant to be a guide to prompt questions.

Appendix 4

Appendix 4.1

Table A4.1: Demographic characteristics of maternity care providers and type of adverse neonatal experience

QID	ID	Profession[1]	Facility[2]	Region[3]	Sex[4]	Years of practice	Type of neonatal experience[5] (N=48)			
							Asphyxia (n=39)	Prematurity (n=28)	Infection (n=28)	Death (n=18)
21	N1	Midwife	Hospital	UER	F	2	√	√	√	×
5	N2	Midwife	Clinic	UER	F	11	×	√	√	√
20	N3	Midwife	Clinic	UER	F	1	×	×	√	×
7	N4	Midwife	Clinic	UER	F	9	√	×	√	√
17	N5	Midwife	Clinic	UER	F	1	√	√	×	×
6	N6	Doctor	Hospital	UER	M	4	√	√	√	√
9	N7	Midwife	Clinic	UER	F	4	√	×	√	√
18	N8	Midwife	Clinic	UER	F	2	×	√	×	×
11	N9	Midwife	Hospital	UER	F	4	√	√	√	√
19	N10	Doctor	Hospital	UER	M	4	√	√	√	×
22	N11	TBA	Home	UER	F	10	√	√	√	×
57	B1	Midwife	Hospital	BAR	F	14	√	√	×	√
53	B2	Doctor	Hospital	BAR	M	1	√	√	√	√
55	B3	Midwife	Hospital	BAR	F	7	√	√	×	×
63	B5	TBA	Home	BAR	F	31	√	√	√	√
65	B4	Midwife	Clinic	BAR	F	1	√	×	√	×
59	B6	TBA	Home	BAR	M	6	√	×	×	√
71	B7	TBA	Home	BAR	F	31	√	×	×	×
67	B8	Midwife	Clinic	BAR	F	10	√	√	×	×
70	B9	TBA	Home	BAR	F	21	√	√	√	√
68	B10	TBA	Home	BAR	F	20	×	√	×	×
69	B11	TBA	Home	BAR	F	31	√	×	×	√
13	G1	CHN	Clinic	GAR	M	2	×	×	√	×
42	G2	TBA	Home	GAR	F	25	×	×	×	√
34	G3	TBA	Home	GAR	F	20	√	×	√	×

Table A4.1(cont'd): Demographic characteristics of maternity care providers and type of adverse neonatal experience

QID	ID	Profession[1]	Facility[2]	Region[3]	Sex[4]	Years of practice	Type of neonatal experience[5] (N=48)			
31	G4	TBA	Home	GAR	F	5	√	×	×	×
29	G5	TBA	Home	GAR	F	4	√	×	×	×
37	G6	TBA	Home	GAR	F	30	√	×	×	×
27	G7	TBA	Home	GAR	F	40	√	×	×	×
43	G8	TBA	Home	GAR	F	15	√	×	×	×
28	G9	TBA	Home	GAR	F	20	√	√	×	×
30	G10	Midwife	Clinic	GAR	F	6	×	√	×	×
36	G11	Midwife	Hospital	GAR	F	3	√	√	√	×
33	G12	Midwife	Clinic	GAR	F	2	√	√	√	×
32	G13	Midwife	Clinic	GAR	F	24	×	×	√	×
38	G14	Midwife	Clinic	GAR	F	3	√	√	√	×
41	G15	Midwife	Clinic	GAR	F	10	√	√	√	√
23	G16	Midwife	Clinic	GAR	F	7	√	√	√	×
40	G17	Midwife	Hospital	GAR	F	3/12	√	×	×	×
39	G18	Midwife	Clinic	GAR	F	8	√	√	√	×
35	G19	Midwife	Hospital	GAR	F	2	√	√	√	√
7	G20	Midwife	Clinic	GAR	F	9	√	×	×	√
26	G21	Doctor*	Hospital	GAR	M	29	√	√	√	×
15	G22	Doctor	Hospital	GAR	M	10	×	√	×	×
46	G23	TBA	Home	GAR	F	30	√	×	√	√
45	G24	TBA	Home	GAR	F	50	√	√	√	×
44	G25	Midwife	Clinic	GAR	F	3	√	√	√	√
14	G26	TBA	Home	GAR	M	23	√	×	√	√

1- TBA: Traditional birth attendant; CHN: Community Health Nurse; *(Asterisk): Doctor in a private hospital
2- Clinic: Refers to a CHPS compound or Community health centre
3- UER: Upper East Region, Ghana; BAR; Brong Ahafo Region, Ghana; GAR: Greater Accra Region
4- M: Male; F: Female
5- √: Experienced; ×: Not experienced