Centre for International Health

Neonatal Deaths in a Rural Area of Bangladesh: An Assessment of Causes, Predictors and Health Care Seeking Using Verbal Autopsy

Md. Hafizur Rahman Chowdhury

This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University of Technology

July 2008

DECLARATION

"To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university."

Signed and Dated Declaration:____

ABSTRACT

Poor neonatal health is a major contributor to mortality in under-five children in developing countries, accounting for more than two thirds of all deaths in the first year of life, and for about half of all deaths in children under-five. A major constraint to effective neonatal survival programmes in developing countries, such as Bangladesh, has been the lack of accurate epidemiological data on neonatal deaths. The current study aimed to (1) describe the causes of neonatal death in a rural sub-district of Bangladesh; (2) describe associated birth and obstetric characteristics of neonatal deaths; (3) describe the patterns of care-seeking practices during the fatal neonatal illness episode; (4) compare deaths and care-seeking patterns between the Maternal and Child Health and Family Planning (MCH-FP) service area of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) and the adjoining government service area; (5) identify the predictors of neonatal deaths; and (6) assess the accuracy in assigning causes of death from verbal autopsy data by comparing physician review with medical assistant review and computer-based algorithm.

This study was carried out during 2003 and 2004 in a demographic surveillance area in the Matlab rural sub-district of eastern Bangladesh. The surveillance system covers a population of ~220,000 and is maintained by ICDDR,B. Community health workers (CHRW) visit each household monthly to record vital demographic, morbidity and health care seeking data. Half of the surveillance population receives MCH-FP services from ICDRR,B (ICDDR,B service area) and the remaining half receives standard government services (government service area).

Verbal autopsies, consisting of retrospective interviews with caregivers of recently deceased neonates about the circumstances leading to their death, were carried out by the staff trained in verbal autopsy. The interviews were held with the mothers of all deceased neonates (n=365) who had died during 2003 and 2004. The verbal autopsy data were then independently reviewed by three physicians and a medical assistant to assign a direct cause of death and an originating cause of death. A computer algorithm using evidence-based clinical signs and/or symptoms was also

used for assigning cause of death. Agreement of at least two of the three physicians was used to determine direct causes of death. Diagnostic accuracy and reliability of medical assistant and algorithm in assigning direct cause of death were evaluated by comparing with the diagnoses provided by the physicians. Linked epidemiological data on all live births in the Matlab area during 2003 and 2004 were also analysed.

There were 365 deaths among the 11,291 live births recorded during 2003 and 2004, yielding a neonatal mortality rate (NMR) of 32.3 per 1000 live births. The NMR was lower in the ICDDR,B area compared to the government area. Of all neonatal deaths, 37% occurred within 24 hours, 76% within three days, 84% within seven days, and the remaining 16% between eight and 28 days of birth.

Five causes accounted for 85% of the deaths: birth asphyxia (45%), prematurity/low birth weight (LBW) (15%), sepsis/meningitis (12%), respiratory distress syndrome (7%), and pneumonia (6%). The majority of neonatal death cases were low birth weight (56%) and singleton births (82%). There were some differences in the distribution of causes of death between the ICDDR,B and government areas, the most notable being prematurity/LBW which was twice as common in the ICDDR,B area than in government area.

Strikingly, more than a third (37%) of the deceased neonates had not been taken to any source of health care for the fatal illness episode, and another quarter (25%) sought care from traditional healers or from unqualified practitioners. Only 37% sought modern biomedical care from a doctor or paramedic.

Among the 365 neonatal deaths, a much higher proportion (48.5%) of the deliveries occurred at a health facility in the ICDDR,B area, compared to 15.3% in the government area. Vaginal delivery was the commonest mode of delivery in both areas, with a higher proportion of caesarean sections in the ICDDR,B area (9.3%) compared with the comparison government area (1.6%).

The verbal autopsy method appears to be highly effective in that agreement on a direct cause of death was reached by at least two physicians in 339 (93%) cases. Using the physician review as the gold standard, the medical assistant review of causes of death demonstrated a sensitivity ranging from 47.7% to 83.5% depending on the cause of death, a specificity ranging from 93.0% to 97.5%, and kappa values ranging from 0.51 to 0.77. Similarly, depending on the cause of death, algorithm demonstrated a sensitivity ranging from 35.6% to 77.4%, specificity ranging from 86.8% to 95.9%, and kappa values ranging from 0.24 to 0.69.

Independent predictors of neonatal mortality included lack of maternal education, single parity, and lack of antenatal care (ANC) during the last trimester. Male sex of the neonate, multiple births, and facility-based delivery were also significantly associated with excess neonatal mortality.

In conclusion, the study highlighted the central role of birth asphyxia, prematurity/LBW, and sepsis/meningitis in neonatal deaths, indicating that the core of interventional packages to prevent neonatal deaths in rural Bangladesh should incorporate these causes. Community awareness about early care seeking, skilled attendance at delivery, and training and integration into mainstream services of traditional/unqualified care practitioners are some of the approaches needed to reduce neonatal mortality further. Improving access to female education and antenatal care would also have beneficial effects on neonatal survival.

This study revealed the value of both review by medical assistant and computer-based algorithm to reliably assign major causes of neonatal deaths from verbal autopsy data. Further research could be undertaken to develop optimal combinations of the medical assistant and hierarchical algorithm for assigning major causes of death in low-resource settings such as Matlab.

ACKNOWLEDGEMENTS

The preparation and completion of this thesis has been a great learning exercise for me over the last three years. From the initial concept, preliminary research objectives and background to the study, I have woven my way through attending workshops, carrying out literature reviews, engaging in theoretical discussions with peers and mentors, and undertaking a range of courses in library use, computer, and epidemiology and statistical analysis. This research trek has continued through preparation and approval of the candidacy proposal, data collection and organization, analysis, and the writing up of the thesis. Throughout this time I have been assisted, supported, educated and nurtured by my supervisors, colleagues, and friends and family members. They have all played part in my transition into a researcher. To them all I proffer my sincere thanks and gratitude. The role of particular people along the way, however, has been so important that they must be singled out for special thanks.

At Curtin University of Technology

Sandra Thompson

My first thanks go to my thesis supervisor Dr Sandra Thompson, Associate Professor at the Centre for International Health, who taught me so much and whose guidance, encouragement, support and critique have been invaluable throughout my doctoral study, and made this thesis completion possible. She mentored me throughout, including accompanying me to numerous research presentations and workshops and introducing me to her wide network of public health researchers at the Telethon Institute of Child Health Research, School of Population Health at the University of Western Australia, the Macfarlane Burnet Institute of International Health, the Maternal and Child Health Centre at La Trobe University, the Australasian and Perth Epidemiological Association, and the Public Health Association of Australia. Her unique combination of competence, critical thinking, tenacity, enthusiasm, friendship, and sensitivity personify the attributes of the ideal academic supervisor.

Kieran McCaul

I give special thanks to my associate supervisor, Kieran McCaul, Senior Lecturer, School of Public Health, for his brilliant statistical guidance. He taught me how to use the Stata software from scratch. I am grateful to him for mentoring and guiding me through the data analysis and for constructive suggestions and comments especially on results sections.

Paola Ferroni

I am grateful to Dr Paola Ferroni, Associate Professor and Head of Centre for International Health, Curtin University of Technology whose encouragement and support helped me to start my doctoral studies in the first place.

Mohammed Ali

I wish to express my sincere thanks to Dr Mohammed Ali, Centre for International Health, Curtin University for his scientific guidance and help in the preparation of this thesis. My special thanks to him for providing me with psychological and physical support during the entire period of my stay in Perth, Australia.

Special thanks to Nerellie Richards and Natasha Forde for their invaluable administrative support and help, always offered with a smile. Thank you to Dilip Roy and Nigel Onamade for their help with computer support.

At the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)

Peter Kim Steatfield

My associate supervisor and Head, Health and Demographic Surveillance Unit, ICDDR,B deserves special thanks as he helped me in every stage of my postgraduate studies at Curtin University. I could not have completed my postgraduate studies without his help and support. He was instrumental in organizing my attendance at the INDEPTH (International Network of Field Sites with Continuous Demographic Evaluation and their Health) sponsored verbal autopsy workshop in Tanzania where standard VA questionnaires based upon the WHO questionnaire were developed, which were subsequently customized, translated, and introduced in the Matlab HDSS. He also facilitated access to much of the data from the HDSS database that formed the basis of this PhD thesis.

Mohammad Yunus

Senior Scientist and Head, ICDDR,B Matlab Health Research Centre, who introduced me to public health. I am grateful for his guidance, encouragement and support at various stages of this study.

Marge Koblinsky

Director, Public Health Sciences Division of ICDDR,B for her encouragement and making early contact with my supervisor at Curtin in regards to my research project. I am grateful to her for providing special leave during my doctoral study period.

I also want to thank my colleagues at ICDDR,B at Matlab and in Dhaka for their generous help and support. I would also like to acknowledge the support of Dr Al Fazal Khan, Dr Shorifa Yesmin and Dr Sabrina Yesmin and Mr Munirul Alam Bhuiyan for reviewing all VA interviews for assigning cause of death. Special thanks are due to the field and computer staff at Matlab who worked with great sincerity and often extra hours on their own initiatives. My special thanks to Mr. Delowar Hossain and Mr. Sajal Kumar Saha in Dhaka for data entry and extracting the required data linking the Matlab Demographic Surveillance System database. I would like to express my sincere thanks to Dr Nurul Alam, a demographer, with whom I teamed up to introduce the new VA tool in Matlab HDSS.

Warm thanks also go to the bereaved families in Matlab who welcomed us into their homes and patiently cooperated with us, sharing the details of the history of illnesses and events that led to the death of their child. Thanks are also due to the women in the study area who responded with their reproductive health history to our community health research worker during their routine home visits.

The financial support of the Australian Government through the International Postgraduate Research Scholarship (IPRS), which was supplemented by a Curtin University Postgraduate Scholarship (CUPS) was crucial and the support of ICDDR,B was also very important in ensuring this project could go ahead.

Finally but not least, I would like to acknowledge my debt and gratitude to my loving family; my wife Kaniz Gausia, and son Nafiz for their love, support and encouragement throughout the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

Acronyms	**Full name**
ANC	Antenatal Care
BDHS	Bangladesh Demographic and Health Survey
BDS	Bangladesh Demographic Survey
CHRW	Community Health Research Worker
CSMF	Cause-Specific Mortality Fraction
CI	Confidence Interval
DFID	Department for International Development
DSS	Demographic Surveillance System
FRA	Field Research Assistant
FWA	Family Welfare Assistant
FWV	Family Welfare Visitor
HDSS	Health and Demographic Surveillance System
ICDDR,B	International Centre for Diarrhoeal Diseases Research, Bangladesh
IMCI	Integrated Management of Childhood Illnesses
IMR	Infant Mortality Rate
INDEPTH	International Network of Field Sites with Continuous Demographic Evaluation and their Health
MA	Medical Assistant
MCH	Maternal and Child Health
MDGs	Millennium Development Goals
MHDSS	Matlab Health and Demographic Surveillance System
MMR	Maternal Mortality Ratio
NMR	Neonatal Mortality Rate
OR	Odds Ratio
PRSP	Poverty Reduction Strategy Programme
TBA	Traditional Birth Attendant
UNICEF	United Nation Children Emergency Fund
VA	Verbal Autopsy
VHW	Village Health Worker
WHO	World Health Organization

MAP OF BANGLADESH

Important Indicators of Bangladesh (NIPORT, 2003 & 2005)

- Population: 140 million
- Life Expectancy: 62
- Malnutrition: 52% of under-five children
- Infant Mortality Rate: 65/1000 live births
- Neonatal Mortality Rate: 41/1000 live births
- Under-Five Mortality Rate: 88/1000 live births
- Maternal Mortality Ratio: 320/100,000 live births
- Birth at home: 91%

CHAPTER 1
Introduction

1.1 Background

The reduction of child and maternal deaths to achieve the Millennium Development Goals (MDG) (United Nations Millennium Declaration 2000) by 2015 remains a major challenge for many developing countries, including Bangladesh. Despite major improvements in infant and child survival in developing countries in recent decades, the situation with regards to neonatal mortality rate (death within the first 28 days of life) has remained relatively static. The reduction in infant and child mortality has been mainly due to post neonatal interventions such as improved immunization, oral dehydration therapy for diarrhoea, management of pneumonia and malaria at the community level, vitamin A supplementation, and promotion of breastfeeding (WHO 2005; Parker 2005; Moss et al. 2002; Lawn, Cousens, and Zupan 2005; Ahmed et al. 2001).

Until the declaration of the MDG, the lack of awareness among health professionals and policy makers about the magnitude of neonatal mortality had meant that neonatal health was a low priority area in the health programmes of developing countries (Martines et al. 2005). Neither the safe motherhood initiative nor the Integrated Management of Childhood Illnesses (IMCI) had adequately addressed the critical neonatal period when most infant deaths took place (Lawn, Cousens, and Zupan 2005). As a result, some policy makers are of the opinion that the MDG of reducing neonatal mortality by two thirds by 2015 may be overly ambitious (Travis et al. 2004).

Information on neonatal mortality characteristics such as timing of death, cause of death, associated risk factors, health care seeking patterns during illness and cost effectiveness of interventions would be helpful in planning appropriate health programmes to cut down the high rate of neonatal deaths.

Globally, an estimated 130 million babies are born every year, and of these, 4 million die in the neonatal period, and another 4 million are stillborn (WHO 2005; Lawn, Cousens, and Zupan 2005; Zupan 2005). Neonatal deaths now account for over two thirds of all deaths in the first year of life and for about half of all deaths of children under-five (Lawn et al. 2004; Lawn, Cousens, and Zupan 2005; WHO 2005; Black, Morris, and Bryce 2003; Darmstadt, Bhutta et al. 2005).

Over three-quarters of neonatal deaths globally, numbering around three million newborns, occur during the first week of life with the highest risk in the first day of life (Lawn, Cousens, and Zupan 2005). The risk of dying in the first 4 weeks of life is 10-15 times higher than that during the subsequent post natal period of infancy (1-12 months), and approximately 30 times higher than during the period of young childhood (13-60 months) (Bhutta et al. 2005; Darmstadt, Lawn, and Costello 2003).

In Bangladesh, a South Asian country of 140 million people (Bangladesh Bureau of Statistics (BBS) 2005), it is estimated that there are around 153,000 neonatal deaths every year which contribute 4% to the global neonatal mortality toll (Lawn, Cousens, and Zupan 2005). The neonatal mortality rate ranges from 41 to 52 per thousand live births and accounts for 50% of under-five mortality in the country (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2001, 2005).

According to the Bangladesh Demographic and Health Survey (BDHS) 2004 report, Bangladesh is nearing its target to reduce mortality in under-five children by two thirds by 2015. From 1991-1997, the under-five mortality rate reduction was greater than 5.6% annually, above the required annual reduction of 4.3% needed to meet MDG4. From 1997 until 2001, however, the reduction has been only 1.5% per annum (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2001; 2005). Therefore, if Bangladesh aims to achieve the Millennium Development Goal-4 (MDG 4) or the wider Poverty Reduction Strategy Programme (PRSP) goal of reducing under-five mortality by two-thirds by 2015, there is an urgent need to strengthen and implement evidence-based cost effective preventive and curative interventions to reduce neonatal deaths.

A major constraint to planning neonatal health programmes in developing countries, such as Bangladesh, has been the lack of population level data on causes of neonatal deaths and the health impact of many interventions currently being considered for inclusion in the neonatal health programme. As the great majority of neonatal deaths in these countries occur at home, outside the formal health care setting, it is difficult to ascertain the cause of death and to know the health care seeking patterns during the fatal illness episode. In such situations, verbal autopsy (VA) can be a valuable, low-cost and practical tool to ascertain cause of death.

VA is a practical tool for assigning a probable cause of death where routine death registration is non-existent or inadequate and autopsies are rarely available. The VA methodology utilizes retrospective information collected by interview of care givers/family members about the symptoms, signs, care seeking and other events related to the deceased and their illness /circumstances prior to death (Fauveau 2006).

However, processing the VA interview data requires appropriate methods to determine a cause of death. There are a number of methods for interpreting VA interviews to arrive at a cause of death. These include review by a medical assistant, use of algorithm, neural networks and probabilistic approach. Each method has its advantages and disadvantages in terms of validity, cost effectiveness, complexity of technique and repeatability. These will be discussed in detail in the literature review chapter. Physician review is often used for interpreting VA interviews, although this requires a considerable amount of scarce physician time, particularly when multiple physicians are used to interpret each VA to increase the possibility of obtaining an objective consensus (Quigley et al. 2000; Soleman, Chandramohan, and Shibuya 2006).

The Health and Demographic Surveillance System (HDSS) in Matlab, a rural area in south-eastern Bangladesh, has been using VA for many years to ascertain the causes of death in its catchment population. Until 2002, fieldworkers used to collect an open-ended death history for all deaths, and a medical assistant had to assign a cause of death based on this information. It has been observed that a significant proportion of neonatal, adult and elderly deaths in Matlab were classified in undiagnosed cause of death (ICDDRB 2003). Neonates contribute significantly to infant and the under-five mortality rate in Bangladesh as well as in Matlab (HDSS 2002; Mercer, Haseen et al. 2006; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). Although infant and under-five mortality rates are relatively low in comparison to national levels, the neonatal mortality rate has been stagnant over the last few years pointing to a weakness of this component of the project activities in Matlab. With slow progress in neonatal survival, and a growing recognition of its contribution to the under-five mortality, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has been giving greater attention to understanding the causes of neonatal death in order to strengthen project activities with available evidenced-based interventions (ICDDRB 2003).

Accordingly, HDSS introduced three new VA questionnaires in the Matlab area in 2003 addressing different age groups of deceased, including one for neonatal deaths. The latter tool also included a section on care seeking during the fatal illness episode.

Neonatal and maternal mortality are complementary public health priorities. As the great majority of neonatal and maternal deaths occur around delivery or immediately after delivery in the early postpartum period, health facility-based delivery is considered a key strategy to improving neonatal and maternal survival. Antenatal care, a multiple purpose strategy, is another cost-effective option for reducing neonatal and maternal morbidity and mortality (Bhutta et al. 2005; Filippi et al. 2006). Only 9% of deliveries in Bangladesh take place in health facilities and less than half of mothers receive one session of antenatal care, although there is a wide network of such facilities throughout the country (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005; National Institute of Population Research and Training (NIPORT) et al. 2003). However, the rate of institutional delivery and antenatal care are considerably higher in the ICDDR,B area in Matlab covering a population of 110,000, with about 27% of deliveries occurred in health facilities in 2001 (Chowdhury et al. 2006). This is because of the intensive maternal and child health activities carried out by ICDDR,B in the area.

The HDSS has been collecting standard health and demographic information both from the ICDDR,B serviced area (intervention area) as well as the neighbouring government serviced area (comparison area with a similar population of 110,000) (HDSS 2004). This has provided an opportunity to examine different aspects of neonatal deaths including a population level comparison of the impact of antenatal care between women who received such care and those who did not.

Community Health Research Workers (CHRW) in the Matlab HDSS collect information on pregnancies, births, deaths, migrations, marriages, and divorces. During 2003 and 2004, CHRWs collected data on these events through monthly home visits. Data on selected factors related to live births and neonatal deaths were also obtained during monthly home visit. These included information on antenatal care and place of delivery (HDSS 2004). When a death was identified during their monthly home visits, a health worker trained in VA interviewed the mother or a close family member within 2-6 weeks of death at the home of the deceased. The interview data was then independently reviewed by three physicians and a medical assistant to assign direct and originating causes of death using ICD-10 codes.

The research described here analyses neonatal deaths to gain an understanding of direct causes of death, differentials, associated maternal and newborn characteristics, health care seeking patterns during the fatal illness episode, and the predictors of neonatal deaths. Data analysed were obtained using two sources: verbal autopsies data using 2003 and 2004; and data on live births linked with data on maternal socio-demographic and reproductive characteristics from the HDSS database.

The other main objective of the study involved the evaluation of alternative methods for assigning causes of death obtained from verbal autopsies. The gold standard or reference diagnosis was physician review, where at least two out of three doctors agreed on a cause of death (COD). The alternative methods are the medical assistant (MA) review and computer-based hierarchical algorithm for assigning cause of death, which were compared against the standard of physician review. Evaluation of these methods was expected to help with assessing their cost-effectiveness.

1.2 Brief Background of the Research Context

The medical doctor who is also the doctoral candidate has been employed as the senior physician and manager of ICDDR,B's Matlab Health Research Centre since 1999. He (doctoral candidate) was also the local technical supervisor of the Matlab Health and Demographic Surveillance System (HDSS), with special emphasis on VA. As previously mentioned, ICDDR,B has been collecting and compiling health and demographic information over the last 40 years to conduct and evaluate new programme interventions. This work has been crucial in the development of numerous life-saving solutions, such as oral rehydration solution for diarrhoea, for a range of common health problems, which have been extensively reported in the scientific literature (ICDDRB Web Page).

Although the Matlab HDSS has been collecting information on cause of death since 1966, there were a number of shortcomings in the VA methodology being used at that time:

1. A large proportion of neonatal deaths in the Matlab DHSS area could not be classified due to inadequate data about the causes of death. Among the several reasons for this, one related to difficulties in obtaining required information on specific signs and symptoms that could reliably help in assigning cause of neonatal death. Another was the difficulty faced by non-medically qualified interviewers in eliciting relevant information during open-ended questioning.

2. There were no structured standardised VA questionnaires to investigate neonatal deaths, including the collection of information of health care seeking behaviour during the fatal illness episode.

3. Lack of a feasible evaluated method for assigning cause of death that could be routinely used in the surveillance.

In 2002, ICDDR,B received a grant from the Department for International Development (DFID), United Kingdom for improving HDSS activities including VA. The doctoral candidate attended a workshop in Tanzania sponsored by

INDEPTH (the International Network of field sites with continuous Demographic Evaluation of Population and Their Health in developing countries) that was facilitated by the WHO and Johns Hopkins University. The INDEPTH questionnaires for VA that evolved from the workshop included modules for neonatal, child and adolescent, and adult deaths (INDEPTH Network).

On the doctoral candidate's return from the workshop, he took a lead role in customising and translating the VA questionnaires into the local language, training VA staff, and piloting the questionnaires in the Matlab DHSS during 2002. The new VA instrument was introduced in Matlab from January 2003. Three physicians and a medical assistant were trained in assigning cause of death and he continued to oversee the data collection. The information collected since 2003 thus provides an opportunity to analyse a complete and reliable data set on the patterns, causes, and associated factors of neonatal deaths, and to evaluate alternative methods for assigning cause of death.

Based on the work the doctoral candidate had undertaken in the study design, he pursued admission to the doctoral programme at the Centre for International Health at Curtin University in Western Australia. After candidacy approval, he returned to Bangladesh to coordinate and finalise data cleaning and organization from the neonatal VA component of the surveillance study. The data organization included assigning cause of death for all VA interviews by three physicians and medical assistant and the computerization of VA information including information on health care seeking. With the help of a programmer, he also abstracted information of live births during 2003 and 2004 along with related maternal socio-demographic, reproductive, and newborn information.The candidacy proposal was submitted to and approved by the ICDDR,B Research and Ethical Review Committee and the Human Research Ethics Committee at Curtin University of Technology.

1.3 Purpose/Goal of the Study

The purpose of the study was to gain an understanding of epidemiological and health care seeking patterns in relation to neonatal deaths in a rural area of Bangladesh, and to evaluate alternative strategies for assigning causes of death from verbal autopsies.

1.3.1 Specific objectives

(1) To describe cause of neonatal death (direct cause) in rural Bangladesh using VA

(2) To evaluate the performance of medical assistant and computer-based (hierarchical) algorithm compared to physician agreement as reference diagnosis in assigning direct cause of death.

(3) To describe maternal reproductive and the newborn's birth characteristics associated with neonatal deaths

(4) To describe the source of health care advice and its differentials during the fatal illness episode

(5) To compare neonatal deaths and health care seeking patterns during fatal illness episode between ICDDR,B and government service area

(6) To examine the effect of demographic, reproductive and newborn characteristics on neonatal survival

1.4 Significance of the Study

There is a critical gap in knowledge about cause of neonatal death and associated reproductive, socio-demographic factors in rural Bangladesh. Such knowledge would be valuable for health programmers and policy makers in planning effective maternal and neonatal and child survival programmes.

Similarly, little is known about health care seeking during the fatal neonatal illness episodes. Such information can be important for improving health care delivery. It has been known that lack of or delay in care seeking causes 70% of child deaths (WHO 2005). At this moment, there are a large number of neonatal health programmes operating in Bangladesh. For the most part, however, they are not planned around reliable information about the health care seeking preferences or practices of parents at the community level.

Understanding the predictors that contribute to neonatal survival and the various interventions that might reduce the risk factors is a necessary first step for designing a strategy for advancing neonatal survival activities. Antenatal care use and place of delivery are often advocated for reducing maternal morbidity and mortality, but there are few community-based studies that have assessed the role of these factors on neonatal survival. This study examines the effect of maternal factors and the characteristic of the newborn on neonatal survival. Relevant maternal factors for consideration include socio-demographic and reproductive variables including uptake of antenatal care and whether delivery occurs within a health facility. The study finding will help programme manager and policy maker to design or strengthen interventions appropriate for improving neonatal and maternal survival.

Finally, there is a great need to develop and evaluate an inexpensive, appropriate, and accurate technique for assigning causes of neonatal deaths in the community. Due to the scarcity of trained physicians and the expense of utilizing physician time in the rural community, primary health care workers such as medical assistants need to be considered for this purpose. Computer-based (hierarchical) algorithms are another inexpensive option. The proposed study examined the reliability and accuracy of both MA and computer-based, hierarchical algorithm for assigning cause of deaths.

1.5 Definition of Terms

Stillbirth: babies born after 22 weeks of gestation who showed no body movement, made no sound, or did not cry after birth

Live birth: defined as an infant who moved, made a sound or cried or breathed at birth

Perinatal death: includes still birth and death in the first week of life

Neonatal death: the death of a live born baby during the period that commences at birth and ends 28 completed days after birth

Early neonatal death: neonatal death in the first week of life

Late neonatal death: death of a baby aged between 7 and 28 days

Perinatal Mortality Rate (PMR): number of stillbirths (babies born after 22 weeks of gestation) and number of early neonatal deaths expressed per 1,000 total births

Neonatal Mortality Rate (NMR): number of deaths among live births during the first 28 days of life per 1,000 live births

Early Neonatal Mortality Rate (ENMR): number of deaths of neonates up to 7 days of age per 1,000 live births

Late Neonatal Mortality Rate (LNMR): number of deaths of neonates of 7 days to 28 completed days of life per 1,000 live births during a reference year.

Infant Mortality Rate (IMR): number of deaths between birth and one year of age per 1,000 live births.

Under-five mortality rate: number of deaths between birth and five years of age per 1,000 live births

Low Birth Weight (LBW): birth weight less than 2,500 gm

Premature birth: babies born before 37 weeks of gestation

Direct cause of death: Disease or condition directly leading to death. This does not refer to the mode of dying e.g. heart failure, respiratory failure, but rather to the disease, injury or complication that caused death.

Originating cause of death: The disease or injury, which initiated the train of morbid events leading directly to death or the circumstances of accident or violence which produced the fatal injury.

Cause-specific Mortality Fraction (CSMF): The CSMF is the proportion of deaths due to cause "X" divided by the total number of deaths in that age group; in the case of neonatal deaths, the denominator is limited to the deaths among aged 0-28 days.

Sensitivity: In the context of the study, sensitivity refers to the proportion of cases there was true positive agreement between the medical assistant/algorithm and the physician-assigned specific disease as a cause of neonatal death. A high sensitivity indicates a low false negative rate, meaning that the rate of misclassification or wrong assessment by the MA or algorithm was low.

Specificity: Specificity refers to the proportion of cases there was true negative agreement between MA/algorithm and the physician-assigned specific disease as cause of neonatal deaths. A high specificity indicates a low false positive rate, meaning that there would be a low likelihood of misclassification or wrong assessment by MA or algorithm

Positive Predictive Values (PPV): This refers to the proportion of cases of algorithm/ MA-assigned specific disease where the physician agreed on the same disease as cause of death. A high PPV for the MA or algorithm indicates a low false positive rate, meaning that the MA/algorithm did not erroneously assign the cause where such a cause was not assigned by the physician.

Kappa Score (k): The kappa statistic is a reliability test, which gives the measure of agreement between two methods after adjusting for chance agreement. The kappa can only be used for categorical outcomes, such as the presence or absence of a specific disease as a cause of neonatal death.

VA: VA is an interview to collect retrospective information from close family members or carers of an individual who has died outside the health care system in order to establish a possible biomedical cause of death.

1.6 Organization of Thesis

1.6.1 Chapter One

This introductory Chapter One has provided the background and justification for the study, research objectives, and the significance of the study.

1.6.2 Chapter Two

This chapter reviews the literature on neonatal health and mortality arising from studies mainly carried out in developing countries. The literature covered includes magnitude and importance of neonatal mortality, current public health policy including the UN MDG, the use of VA tools, and risk factors for neonatal deaths. Various public health interventions and strategies for neonatal survival in developing countries are also reviewed.

1.6.3 Chapter Three

This chapter describes the study methodology including the research setting, study design, sampling, and data collection methods. The strategies to ensure data reliability and quality are also described, as are ethical considerations.

1.6.4 Chapter Four

This chapter provides a descriptive overview of neonatal death cases. Epidemiological information on the rate of neonatal mortality and care seeking during the fatal illness episodes are presented. Associated maternal complications and clinical signs of neonatal illnesses are also described.

1.6.5 Chapter Five

This chapter describes the rules applied to determine the reference/gold standard physician assigned cause of death. This gold standard physician assigned (at least two physicians agreeing) cause are used to report the distribution of cause of death and their differentials at Matlab. Cause-specific mortality fraction (CSMF) is reported for each physician, MA, algorithm and for gold standard physician assigned cause for comparison. The reliability (kappa score) and diagnostic accuracy (sensitivity, specificity, PPV) of medical assistant (MA) and algorithm methods compared with physician for assigning major cause of neonatal death are presented.

1.6.6 Chapter Six

This chapter describes the distribution of various predictors of neonatal mortality identified in the study. It also presents crude and adjusted odds ratios for predicting neonatal death. The interaction between antenatal care use during the last trimester and place of delivery are examined to identify women who are at increased risk of sustaining neonatal death. Model statistics are used to examine goodness of data fit with the model for logistic analysis.

1.6.7 Chapter Seven

This chapter discusses findings of the study in the local, national and global context. Policy and research implications arising from the study are discussed.

CHAPTER 2
Literature Review

2.1 Introduction

This chapter reviews the literature on neonatal health globally and in Bangladesh. Among the issues covered are the United Nations Millennium Goals (MDG) in relation to neonatal health, risk factors and causes for neonatal mortality, methodological considerations in the measurement of neonatal mortality with particular reference to VA, and health care seeking during fatal neonatal illness episodes. Interventions to reduce neonatal mortality are also reviewed.

A systematic search strategy was used to identify relevant literature on the issues above. Peer-reviewed journal publications were initially sourced by searching for key terms. Common key words for the search included neonatal mortality, VA, validation, developing countries, Bangladesh, risk factors, neonatal intervention, and health care seeking. Synonyms for key terms were also used, as were a number of advanced search strategies to maximise output. In addition, relevant articles were identified from the bibliographies of the published papers. For identifying primary articles, a large number of scholarly electronic databases through the Curtin University library system were searched including Pub Med, Pro-quest 5000, Science Direct, Google Scholar and Web of Sciences.

A general internet search using mainly the Google search engine also yielded material from the websites of organizations involved in the doctoral research topic area. These institutions included the World Health Organization (WHO), International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), International Network of Field Sites with Continuous Demographic Evaluation of Population and Their Health in Developing countries (INDEPTH), United Nations Development Programme (UNDP), United Nations Children Emergency Fund (UNICEF), and the World Bank (WB).

In total, 178 articles consisting of individual studies, meta-analysis, and review papers, were included in the review. The main strategy employed for inclusion or exclusion of particular papers was the relevance to the study objectives.

2.2 Childhood Death Globally

Globally there are 10.8 million deaths in children under-five years of age. The overwhelming majority of these deaths occur in developing countries, with six countries (China, India, Pakistan, Nigeria, Congo and Ethiopia) accounting for almost 50% of these deaths and 42 countries for 90% (Black, Morris, and Bryce 2003; WHO 2005). Among deaths in under-five children in South-East Asian countries, 90% occurred in six countries Bangladesh, Bhutan, India, Nepal, Myanmar and Indonesia (see Figure 2-1) (WHO 1999).

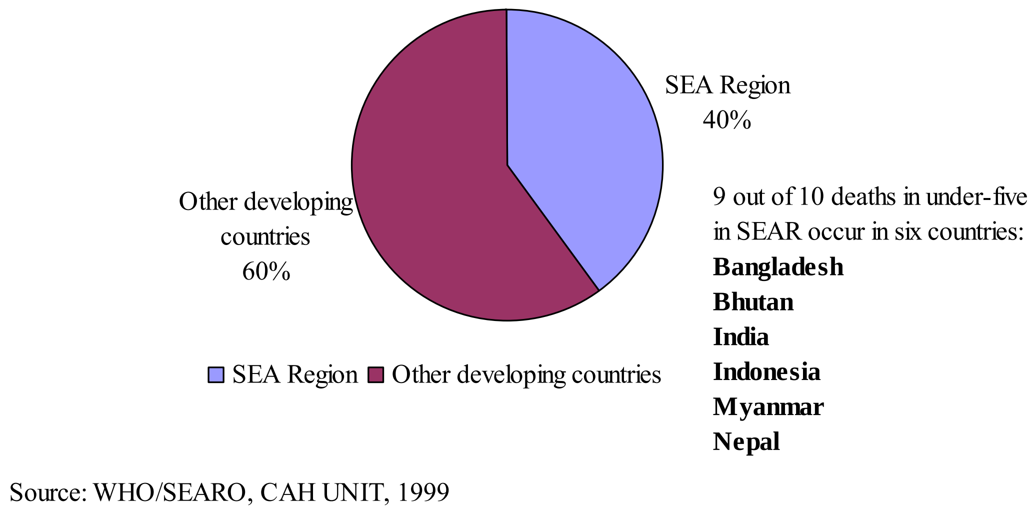
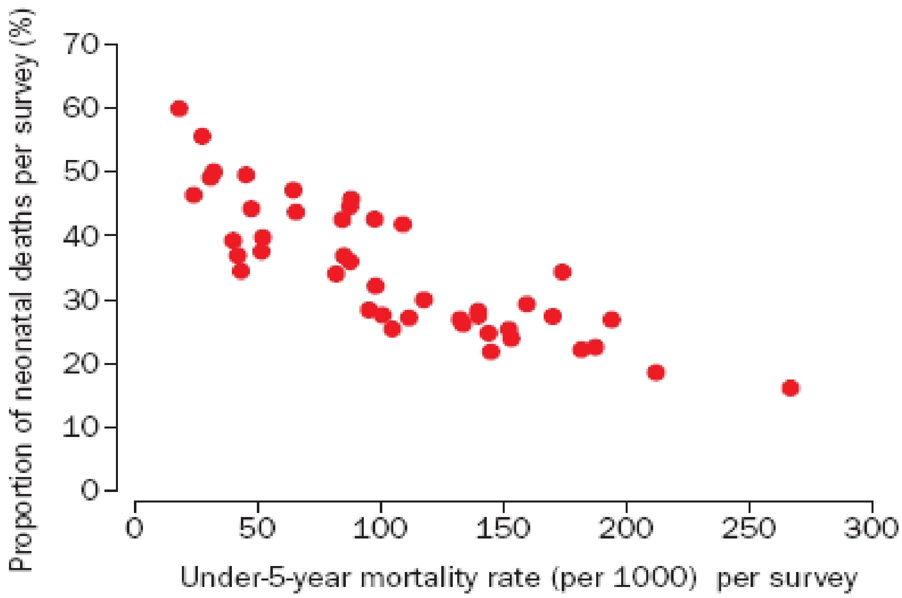


Figure 2-1: Proportion of deaths in children under-five years of age in the Southeast Asian (SEA) Region to global deaths, 1999

What is striking about the pattern of mortality in children under-five years is the contribution of the neonatal age group (first 28 days of life). Four million or more than a third (38%), of the 10.8 million deaths in children under-five occur during these first 28 days of life (Black, Morris, and Bryce 2003; Lawn, Cousens, and Zupan 2005).

An interesting relationship between under-five and neonatal mortality, that has been observed in developing countries, is that the relative contribution by neonatal mortality to overall under-five mortality varies according to the absolute magnitude of child mortality. Black and colleagues (Black, Morris, and Bryce 2003) analysed data from 44 demographic and health surveys and found that just over 20% of child deaths occurred in the neonatal period in countries with the highest child mortality rates, whereas in countries with under-five mortality rates less than 35 per 1000 live births, 50% of death occurred during the neonatal period (see Figure 2-2).



Source: Black et al. Lancet 2003

Figure 2-2. Relative contribution of neonatal mortality according to level of under-five mortality

2.3 The State of Neonatal Health Globally

Of the estimated 130 million births every year, 4 million die in the neonatal period, while another 4 million are stillbirths (Lawn, Cousens, and Zupan 2005; WHO 2005; Zupan 2005). Neonatal death now accounts for over half of all deaths in the first year of life and for about 40% of all deaths of children under-five (Bhutta et al. 2005; Black, Morris, and Bryce 2003; Lawn, Cousens, and Zupan 2005; WHO 2005).

There is a clear relationship between age of the child and its risk of dying. The risk of dying in the first 4 weeks of life is 10-15 times higher than the risk of dying during the subsequent post natal period of infancy (1-12 months), and approximately 30 times higher than during the period of young childhood (13-60 months). Over three-quarters, or 3 million, of the neonatal deaths occur during the first week of life with the highest risk in the first day of life (25-45%) (Lawn, Cousens, and Zupan 2005; Darmstadt, Lawn, and Costello 2003).

2.4 Regional Perspectives of Neonatal Death

As mentioned earlier, neonatal deaths are concentrated mostly in poor developing countries. According to WHO estimates, 99% of neonatal deaths occur in low and middle income countries which have an average neonatal mortality rate (NMR) of 33 per 1000 live births. This is in contrast to the average neonatal mortality rate of 4 per 1000 live births in industrialised, developed countries (Lawn, Cousens, and Zupan 2005). The contribution of neonatal death to overall under-five child deaths varies between regions, it being highest in south Asian countries (50% of all under-five deaths) while the corresponding proportion for African countries is 24% (Lawn, Cousens, and Zupan 2005; WHO 2005; Hyder, Wali, and McGuckin 2003). Only ten countries from Asia and Africa account for two-thirds of all neonatal deaths with the largest number of deaths being from India (see Table 2-1).

Table 2-1. Countries with largest numbers of neonatal deaths worldwide

	Number of neonatal deaths (1000s)	% of global neonatal deaths (3.99 million)	NMR (per 1000 live births)
India	1098	27%	43
China	416	10%	21
Pakistan	298	7%	57
Nigeria	247	6%	53
Bangladesh	153	4%	36
Ethiopia	147	4%	51
Congo	116	3%	47
Indonesia	82	2%	18
Afghanistan	63	2%	60
Tanzania	62	2%	43
Total	2682	67%	

Source: (Lawn, Cousens, and Zupan 2005).

The Asia-Oceania region (South Asia, East Asia, South-East Asia, West Asia, and Oceania) accounts for 76 million annual live births, representing 54% of the world's total births. However, the region accounts for 66% (3.3 million) of the total neonatal deaths in the world. Among the Asia Oceania region, there are only five countries (Australia, Hong Kong, New Zealand, Singapore and Japan) that have a NMR below 5 per 1000 live births. These five countries account for 1.7 million or 2.3% of the total births of the Asia Oceania Region. In contrast, South Asian countries such as Bangladesh, India, Pakistan, and Nepal have NMRs ranging from 41-57 per 1000 live births. Sri Lanka is an exception with a NMR between 16-19 per 1000 live births (Yu 2003; Bhutta et al. 2004).

2.5 Millennium Development Goals (MDG)

In September 2000, world leaders at the United Nations formulated a vision to reduce poverty, hunger and disease in the world in order to improve survival for mothers and infants, provide better education for children, ensure equal education opportunities for women, and secure a healthier environment. This vision was endorsed by 189 countries in the shape of eight MDG which set out a time-bound roadmap for achieving the above goals. These goals are the widest commitment in history to address the problems of global poverty and ill health (United Nations Millennium Declaration).

To measure and track the progress of the eight goals, 18 targets and 48 indicators have been identified. Three out of 8 goals, 17 out of 18 targets and 18 out of 48 indicators are related to health. The eight Millennium Goals are:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote sex equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other disease
7. Ensure environmental sustainability
8. Develop a global partnership for development

2.5.1 Fourth millennium development goal (MDG-4) and its progress

This section of review will briefly focus on the importance of neonatal mortality in relation to the fourth Millennium Development Goal, which seeks to reduce child mortality. The goal commits to a target for reducing under-five mortality by two-thirds between 1990 and 2015. The next section describes the progress in reduction of child mortality worldwide, with special reference to neonatal mortality.

2.5.2 Global trends in child mortality

The UNICEF and United Nations have (United Nations Children Fund 2006; United Nations Millennium Declaration) reported the trend and rate of progress of under-five mortality in the last decade. While child survival has improved in every region, at the current rate of progress it is unlikely that the required target of MDG-4 will be achieved in most of the developing countries. The progress is shown in Table 2-2.

Although survival prospects have improved slightly, around 10.5 million children died before their fifth birthday in 2004. While Sub-Saharan African countries contribute 20% of the world's children, they account for 50% of under-five death (Lawn, Cousens, and Zupan 2005). The World Children's Report (United Nations Children Fund 2006) states that the average annual of rate of reduction in Sub-Saharan African countries was 0.7% in 2004, versus the 9.9% annual rate of reduction required to achieve the MDG target by 2015. The progress in the South Asian region where the great majority of death occurs also seems to be sub-optimal. The current rate of under-five mortality reduction in the region is 2.4%, which is comparable to the North American and East Asian regions, but less than the annual 4.5% reduction required to achieve MDG-4.

In contrast, under-five mortality rate has reduced markedly in Latin and north American and East Asian countries, with an annual reduction of more than 2.6% during 1990-2004. These countries are well on target to achieve the MDGs even if they progress at a slower rate than during 1990-2004.

Table 2-2. Required annual rate of reduction of child mortality to achieve MDG-4

	Average annual rate of reduction		
	Current		Needed to Achieve MDG4
	1970-1990	1990-2004	2005-2015
UNICEF Region	%	%	%
Latin America/Caribbean	4.1	4.0	1.2
East Asia and Pacific	3.7	3.4	1.5
Middle East/ North Africa	4.4	2.6	2.7
South Asia	2.3	2.4	4.5
Sub Saharan Africa	1.3	0.7	9.9

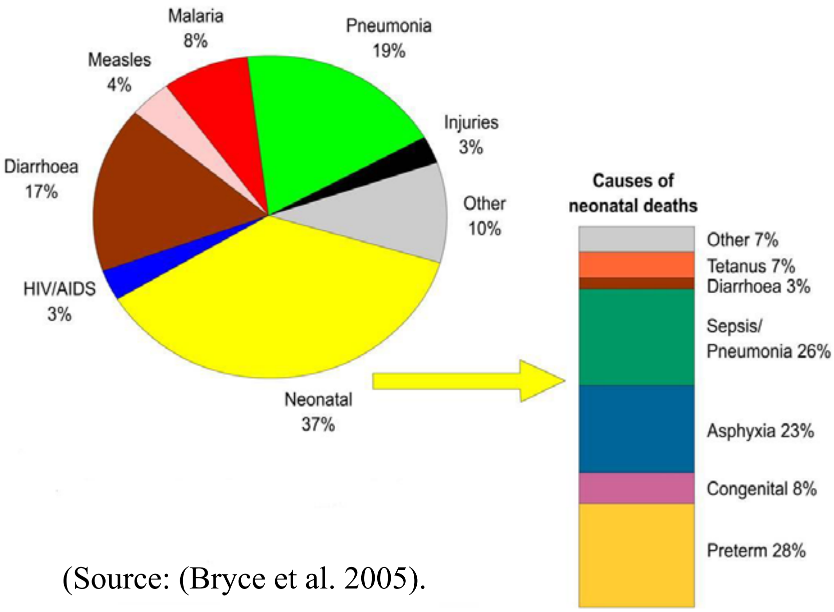
Source:(United Nations Children Fund 2006)

While there has been a substantial improvement in child mortality rates worldwide, this has been limited principally to the post neonatal period (Darmstadt, Black, and Santosham 2000; Darmstadt, Lawn, and Costello 2003; Lawn, Cousens, and Zupan 2005; Moss et al. 2002; Parker 2005; WHO 2005)**.** This reduction is mainly due to successful implementation of immunization, better pneumonia management, oral rehydration therapy and other interventions appropriate to reduce post-neonatal death (Moss et al. 2002; Parker 2005). Inadequate awareness among policy makers and programme managers of the magnitude of neonatal deaths and their contribution to child death may lead to further delay in progress in child survival. Already, concerns have been voiced by health professionals about the slow progress in achieving the target of MDG-4 on time.

2.6 Causes of Under-five and Neonatal Death

Globally, more than a third (38%) of under-five deaths occurs during the neonatal period (see Figure 2-3). The remaining 63% occur in the much larger age group of 1-59 months, and are mostly infectious in origin: pneumonia (19%), diarrhoea (17%), malaria (8%), measles (4%), and HIV/AIDS (3%).

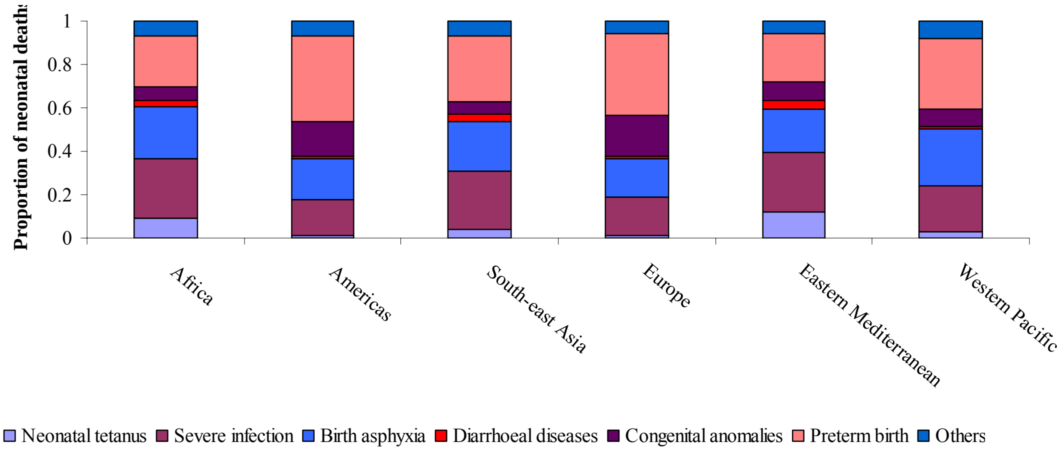
The major causes of neonatal deaths are prematurity (28%), sepsis/pneumonia (26%), asphyxia (23%), tetanus (7%), and congenital anomalies (8%). Low birth weight is an important factor underlying most causes of neonatal death (WHO 2005; Darmstadt, Bhutta et al. 2005; Lawn, Cousens, and Zupan 2005; Black, Morris, and Bryce 2003; Zupan 2005).



(Source: (Bryce et al. 2005).

Figure 2-3.Causes of under-5 and neonatal death (yearly average for 2000-03)

The majority of deaths can be prevented through wider implementation of relatively simple and cost-effective interventions that include early detection and treatment of sepsis, skilled care at birth, early and exclusive breastfeeding, kangaroo care of low birth weight and premature babies, and maternal tetanus immunisation (Darmstadt, Bhutta et al. 2005; WHO 2005; Bhutta et al. 2005).



Source: World Health Report, 2005

Figure 2-4. Causes of neonatal death in WHO regions, estimates for 2000-2003

There is a scarcity of reliable data in most developing countries on causes of neonatal death, as most of these neonatal deaths occur outside the formal health system. However, a number of epidemiological studies suggest that developing countries have similar patterns of causes of neonatal death. Prematurity and low birth weight are the top causes of death in the hospital setting; infections leads the list of causes of death in the community, followed by birth asphyxia and low birth weight (LBW). The incidence of LBW, a major contributor to death, is high in the countries of the South-east Asian region, ranging from 7% in Thailand to 30% in Bangladesh (Bhutta et al. 2004; WHO 2002).

The major difference between developing and developed countries in the causes of neonatal death is that infectious diseases and birth asphyxia predominate in the former, while prematurity and congenital anomalies assume a much higher proportion of causes in the latter, as can be seen in the Figure 2-4.

2.7 Perinatal and Neonatal Mortality in Bangladesh

In Bangladesh, a south Asian country of 140 million people (Bangladesh Bureau of Statistics (BBS) 2005), it is estimated that there are around 153,000 neonatal death every year, contributing 4% to the global burden of neonatal deaths (Lawn, Cousens, and Zupan 2005). The neonatal mortality rate in the country ranges from 41-52 per 1,000 live births depending on the geographic area (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2001).

The Bangladesh Demographic and Health Survey (BDHS) in 2004 found fluctuating progress in the MDG goal of reducing under-five mortality by two-thirds by 2015. From 1991-1997, under-five-mortality rate reduction was greater than 5.6% annually compared to a required annual reduction of 4.3%. From 1997 until 2001, however, the reduction has been only 1.5% per annum (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2001; 2005). There are several reasons that can be postulated for this slowing in progress. It may be attributed to the distribution of time period when under-five death occurs and its causes of death. The BDHS 2004 report shows that neonatal death accounted for almost half of under-five deaths in 2001, while the figure was 39% in 1991. The initial reductions in the under-five mortality rate in the first few years after 1991 are largely attributable to reductions in infectious disease mortality in the post neonatal group. Neonatal deaths due to birth asphyxia and prematurity/low birth weight have not yet been addressed adequately by interventions that improve skilled attendance at delivery, postnatal care and management of low birth weight/prematurity.

A major hurdle in planning neonatal health programmes in developing countries has been the lack of adequate epidemiological information about trends in neonatal mortality rate and the causes of death. There are some difficulties in readily obtaining such information in resource constrained settings, and in this respect the use of simplified methodologies to ascertain such epidemiological information in Bangladesh can be useful. The next section describes the use of VA, an inexpensive and simple tool, to identify causes of neonatal death.

2.8 Causes of Neonatal Death and Use of VA in Bangladesh

Verbal autopsies (VA) have been the preferred method of ascertaining causes of death in Bangladesh since the early 1980s (Bhatia 1989; Baqui et al. 2001; Baqui et al. 1998; Chowdhury et al. 2005; Fauveau et al. 1990; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005).

One of the earliest VA projects on neonatal death was carried out at Matlab in eastern Bangladesh during 1982-83. The study, which covered 945 neonatal deaths, used a physician to interpret VA interviews for assigning probable causes of death. The VA tool was a semi-structured questionnaire with an open section for describing symptoms and events prior to death. A neonatal mortality rate of 57 per thousand live births was found in the Maternal Child Health and Family Planning (MCH-FP) project area in Matlab, while the corresponding rate in the comparison area served by standard government services was 67 per thousand live births. Overall, prematurity, complication of child birth, tetanus, and respiratory tract infection accounted for 75% of all neonatal deaths, with prematurity predominating at 38% of neonatal deaths. The main reason for the lower mortality rate in the MCH-FP project area was the lower incidence of tetanus neonatorum resulting from the high coverage of tetanus prophylaxis among pregnant mothers (Bhatia 1989). However, this VA tool was not formally integrated with the routine demographic surveillance system at Matlab.

A subsequent study in 1985 conducted in a rural sub-district of Tangail district in Bangladesh among 985 mothers found a neonatal mortality rate of 70 per thousand live births. The study found more than five times higher NMR in premature births (222 per 1000 live births) compared to mature newborns (40 per 1000 live births). The major causes of death included tetanus neonatorum (39%), respiratory infection (17%), birth injury (17%) and respiratory distress syndrome (13%). However, the researchers did not mention the method used for assigning cause of death (Rahman and Nessa 1989).

Another study by Fauveau and colleagues in 1986 assessed the cause of perinatal deaths in Matlab using VA, and used physicians for interpreting the interviews. They included 145 deaths during the early (within 7 days of birth) neonatal period. The main causes were prematurity/low birth weight (54%), hypoxia/birth trauma (26%), neonatal tetanus (8%), and respiratory infection (2%). No cause was assigned in 4% of cases (Fauveau et al. 1990).

The importance of prematurity/low birth weight in neonatal mortality revealed in the above studies was reconfirmed in a more recent study in 2001 in Bangladesh that assessed mortality rate among low birth weight neonates. Seven hundred and seventy six low birth weight babies were recruited at hospital and followed up at home after one month of delivery. The study documented an early neonatal morality rate of 133/1000 live births (Yasmin et al. 2001).

The first nationwide attempt to measure child mortality including neonatal mortality using VA was carried out in 1993-1994 through the Bangladesh Demographic and Health Survey (BDHS). The survey covered the deaths occurred between 1988 and 1993 and estimated mortality and cause of death (Baqui et al. 1998). A second survey was carried out in 1996-97 and covered the deaths between 1992 and 1996. A common questionnaire was used for all under-five child deaths. Both surveys used a predefined computer-based algorithm to ascertain cause of death.

Results based on survey data between 1988-93 (neonatal death=311) showed that neonatal tetanus (15%), respiratory infection (11%), and early neonatal death (48% - no cause given) were the main causes of neonatal death, while in 15% no cause could be ascertained. One important limitation of the study was that all neonatal deaths during 0-3 days since births were grouped under early neonatal deaths which limited the understanding of causes of a large number of deaths (Baqui et al. 1998).

The second BDHS survey of 287 neonatal deaths during 1992-1996 was mainly carried out to ascertain whether there had been any changes in the pattern of causes of death. The algorithm used in the survey could not ascertain the cause of deaths during the early neonatal period which comprised 49% of all neonatal deaths. In the remaining cases, the major causes were neonatal tetanus (17%) and respiratory infection (10%), with no cause assigned in 13% of cases. Although the survey documented a decline in under-five mortality, there were no appreciable changes in the pattern of causes of death among neonates (Baqui et al. 1998; Baqui et al. 2001).

The latest nationwide BDHS survey in 2004 used both algorithms and physician reviews to ascertain the cause of death among 326 neonates (BDHS 2005). Initially researchers applied a hierarchical algorithm, and then physicians reviewed unspecified death cases in an attempt to increase the proportion of assignation of causes. The major causes of neonatal death were possible serious infection (33%), birth asphyxia (21%), acute respiratory infection (ARI - 10%), and prematurity/LBW (11%). The study algorithm included all neonatal deaths regardless of timing of death (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005).

Other nationwide surveys on neonatal mortality have also been carried out. In a nationwide wide study during 1992-93, 1019 pregnant women were randomly selected from eight rural areas in Bangladesh in order to investigate causes of neonatal death. They were followed up at home every four weeks and when a neonatal death occurred, mothers were interviewed using a structured VA tool. A total of 50 neonatal deaths were recorded, with 35 deaths in the early neonatal period and the remaining 15 in the late neonatal period. Three physicians reviewed VA interviews independently initially, and assigned direct and originating causes of death. Where there was discordance between the physicians about a case, it was discussed among themselves to arrive at a consensus diagnosis. Sepsis (32%), birth asphyxia (26%), tetanus (15%), and respiratory distress (6%) were the main direct causes of neonatal death. Major originating causes of death were: prematurity/low birth weight (30%), difficult labour (16%), and unhygienic birth practices (16%). In 14% of cases, a direct cause could not be established, and in 34% of cases no originating cause could be assigned. Although the study sample consisted of randomly drawn pregnant women from all the major administrative areas of the country, the small sample of neonatal death limited the generalization of the findings (Chowdhury et al. 2005).

A more recent study in 2003 also investigated causes of neonatal death, using VA as the tool. Of the 381 deaths analysed from 27 non-governmental service areas from all over the country, 40% occurred on the first day of life and 70% in the first seven days. The major causes of death were: birth asphyxia (39%), low birth weight (28%), and infectious disease (15%). The proportion contributed by tetanus was very small (only 1%) (Mercer, Haseen et al. 2006).The table below (Table 2-3) outlines the patterns of causes of neonatal deaths.

Table 2-3. Patterns of causes of death (%) among neonates, various community-based studies, Bangladesh

Cause of death	**A**	**B**	**C**	**D**	**E**	**F**
	%	**%**	**%**	**%**	**%**	**%**
Neonatal tetanus	39.1	15	14.9	16.7	4.2	1.3
Birth asphyxia		26			21.1	38.6
Prematurity/LBW					10.9	27.8
Congenital anomalies			0.9		5.1	
Respiratory infection/pneumonia/ALRI	17.4		11.0	9.8	10.3	6.8
Diarrhoea			1.7	1.0	1.2	1.6
Persistent diarrhoea				0.03		
Diarrhoea and pneumonia			1.0	0.07	0.5	
ARI and persistent diarrhoea				0.03		
Possible pneumonia			6.3	6.3		
Possible diarrhoea				1.4		
Possible pneumonia and diarrhoea			0.3			

Cause of death	A	B	C	D	E	F
	%	%	%	%	%	%
Respiratory distress syndrome	13.0	6				
Other serious infections					33.2	
Sepsis		32				1.6
Birth injury	17.4			3.9		
Jaundice						3.4
Malnutrition			1.5	1.7		
Other causes	13	6		2.3	2.3	
Undetermined					3.4	
Unspecified		14	14.8	12.9	3.9	
Early perinatal/neonatal			47.6	48.8	-	
Total deaths	**69**	**50**	**311**	**287**	**326**	**381**

(A): Tangail, three unions in Ghatail Upazila, Jan-Dec 1995 (Rahman and Nessa 1989) (B) Nationwide from four divisions, 1992-1993 (Chowdhury et al. 2005).
(C): Bangladesh Health and Demographic Survey 1993-94 (Baqui et al. 1998).; (D); Bangladesh Health and Demographic Survey 1996-97 (Baqui et al. 2001).
(E): Bangladesh Health and Demographic Survey 2004 (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005).; (F) Nationwide from 27 NGO sites, 2003 (Mercer, Haseen et al. 2006).

In summary, the current review on causes of death among neonates in Bangladesh demonstrates the wide variation in the categorization of direct causes, questionnaire type, sampling of death cases, and method of assigning cause of death, which may have accounted for some of the differences in reported findings (see Table 2-3). Studies did not use consistent and standardized categories for classifying neonatal cause of death. For example, the absence of a category for "prematurity" or "low birth weight" in some studies almost certainly resulted in some neonatal deaths being classified as respiratory distress, sepsis or tetanus. Studies also used different terms for broad causes of death such as probable, main cause, primary, underlying, originating, and contributing causes without giving a clear definition. For example, some studies considered pregnancy complication as a main cause of death without specifying the underlying or direct cause of death. A clear and consistent definition of cause for neonatal death would have been helpful in comparing cause of death within and across different settings.

2.9 Risk Factors Associated with Neonatal Death

It is now being increasingly recognized that socio-economic, maternal and newborn characteristics contribute substantially to perinatal and neonatal mortality. Neonatal outcomes are affected by maternal health and maternal care throughout the lifecycle, beginning with a girl child, and through to adolescence and pregnancy.

2.9.1 Maternal factors

The Lancet Neonatal Survival Steering Team reviewed and conducted an analysis of maternal risk factors for perinatal and neonatal mortality (Lawn, Cousens, and Zupan 2005). They systematically identified published work on population-based studies in developing countries including Bangladesh, India, Italy, Brazil and African countries. The analysis found that maternal age, pre-pregnancy weight, maternal height, parity and poor obstetric history were significant independent risk factors for perinatal, natal and neonatal mortality. Among antenatal factors, multiple pregnancy, hypertensive disorder, maternal anaemia, maternal infectious disease were significantly associated with increased risk of perinatal or neonatal mortality. Maternal intrapartum complications were highly associated with perinatal and neonatal mortality. In general, complications, especially obstructed labour and malpresentation during delivery were more likely to lead to excess neonatal mortality (see Table 2-4). It was also observed that the death of the mother during delivery was a strong predictor of newborn death (Lawn, Cousens, and Zupan 2005).

Table 2-4. Adjusted odds ratios for various risk factors for neonatal or perinatal death reported from population-based studies

Life-cycle factors	**Adjusted odds ratio**
Maternal age (years)	
<18	1.1-2.3
>35	1.3-2.0
Maternal size	
Height <150cm	1.3-4.8
Pre-pregnancy weight <47 kg	1.1-2.4
Parity	
Primigravida	1.3-2.2
Parity >6	1.4-1.5
Poor obstetric history	
(Perinatal death or instrumental delivery)	1.6-3.5
Antenatal factors	
Multiple pregnancy	2.0-6.8
Hypertensive disorders	
Pre-eclampsia	1.7-3.7
Eclampsia	2.9-13.7
Bleeding per vagina after 8 months	3.4-5.7
Maternal jaundice	2.0-7.9
Maternal anaemia	
PCV<0.21	1.9-4.2
PCV <33%	NS
Maternal malaria (blood test positive)(LBW)	2.2-3.5
Syphilis (perinatal death)	1.7-5.8
HIV (Infant death)	7.2
Intrapartum factors	
Malpresentation	
Breech	6.4-14.7
Others	8.3-33.5
Obstructed labour/dystocia	6.7-84.9
Prolonged second stage	2.6-4.8
Maternal fever during labour(<38°C)	9.7-10.2
Rupture of membranes >24 h	1.8-6.7
Meconium staining of liquor	11.5

Source: (Lawn, Cousens, and Zupan 2005)

The importance of maternal complications on neonatal survival was further highlighted by other community-based studies from Bangladesh. A study in Matlab found that 30% of perinatal deaths were associated with maternal complications such as prolonged/obstructed labour, abnormal foetal position and hypertensive disease of pregnancy (Kusiako, Ronsmans, and Van der Paal 2000). With a maternal mortality rate of 320 per 100,000 live births (National Institute of Population Research and Training (NIPORT) et al. 2003), the implications for perinatal survival in the country are obvious. The contribution of maternal labour complications to perinatal mortality was further evidenced by a rural hospital-based study in Kenya. The study included 910 births, and found that labour complications (haemorrhage, premature rupture of membrane/premature labour, obstructed labour/malpresentation) contributed to 53% of all perinatal deaths. These complications increased the risk of perinatal mortality from 8 to 62 fold, underscoring the need to improve obstetric care in rural areas (Weiner et al. 2003).

The effect of maternal factors on neonatal survival was further examined by Bari and colleagues who used prospectively collected data on maternal socio-demographic, reproductive and delivery factors, and examined their association with perinatal death and early neonatal death. The analysis examined 1007 pregnancy outcomes during 1992-93 using a multistage cluster sampling from four major geographic divisions of Bangladesh. On multivariate logistic regression, low socio-economic status, (48% higher risk compared to higher socio-economic), women with parity of 5 or more (OR 2.18; 95% CI: 1.07-4.44), and assisted delivery or trial labour (OR 5.86; CI: 2.78-12.35) were all associated with a higher risk of perinatal death. Factors that can further increase the risk for such complicated pregnancies include lack of transport during emergencies, birth preparedness and knowledge, and ill-prepared and equipped local hospitals (Bari et al. 2002).

A recent case control study from Bangladesh also reported that complications during delivery increased the odds of neonatal deaths from 2.6 to 3.1 times (Mercer, Haseen et al. 2006). In addition, Matlab Bangladesh reported that multiple births contributed 10% of the neonatal deaths although it constituted around 2% of live births. Young mothers (<20 years), primiparity, short birth interval, and mothers with no schooling were all associated with an increased risk of infant deaths among multiple births (Alam, Van Ginneken, and Bosch 2007).

2.9.2 Newborn characteristics

Sex

Girls have a well described biological survival advantage in the neonatal period (Ulizzi and Zonta 2002). However, this advantage may be offset by sex discrimination during health care seeking. Health services utilization data from several studies from developing countries, including Bangladesh, have revealed reduced care seeking for girls compared to boys (Bhatia 1989; Chen, Huq, and D'Souza 1981; Ahmed et al. 2001). Such sex discrimination can occur even before birth, as evidenced by sex-selective abortions in India and China which have resulted in an estimated excess of 1.7 million male babies per year in those countries (Lawn, Cousens, and Zupan 2005).

Low birth weight/prematurity

Globally, around 18 million infants are born with birth weight of 2500g or less, and half of these are in Asia. Although low birth weight babies account for only 14% of total births, they are directly or indirectly associated with 60-80% of neonatal death (Wardlaw 2004; Paul 1999). Low birth weight, which includes prematurity and intrauterine growth retardation, is an indirect cause or risk factor for neonatal death. In Bangladesh, the risk of death is almost five times higher in preterm than in full term infants who were low birth weight after delivery (OR 4.78; 95% CI: 3.14-7.22) (Yasmin et al. 2001). The importance of prematurity as a risk factor of neonatal mortality was further confirmed by a recent case control study in Bangladesh. The researchers reported prematurity as a significant independent risk factor for neonatal mortality. Prematurity was associated with at least a 7.2 times higher risk of death (adjusted OR 7.2; 95% CI: 3.6-14.4) (Mercer, Haseen et al. 2006). A recent study from Australia showed that small gestational age, prematurity and low birth weight were important determinants of stillbirths and neonatal deaths (Mohsin, Bauman, and Jalaludin 2006).

Seasonality of birth and deaths

Deaths show a seasonal pattern in every nation of the world. It has also been documented that countries with the greatest variation tend to have deaths peak in the winter months with more cardiovascular and respiratory disease deaths. Some of causes of death are linked to climatic conditions (Kynast-Wolf et al. 2006). Data from developed as well as developing countries show that the magnitude of seasonal variation has been declining with improvements in population health (Becker and Weng 1998). The peak season of death in many tropical countries is in the summer. But an earlier study from Matlab Bangladesh found that the peak of death in Bangladesh was in the winter during the period between 1974 and 1980 (Becker 1981).

Another study from Matlab, Bangladesh examined 20,328 deaths for the years 1982-1990 to assess whether there was any decline or shift in the seasonality of death over time (Becker and Weng 1998). The study found that deaths in Matlab exhibited seasonal patterns with total deaths as well as neonatal deaths peaking during winter in the 1982-1990 periods. Compared to the previous period of 1974 to 1980, there was a significant shift in time only for neonatal mortality, for which the peak was nearly a month earlier (November) in the 1982-1990. Aside from neonates, there was no significant difference in time of death peak in the other age groups between 1974-1980 and 1982-1990 periods. The study also found that diarrhoea death peaked in the hot-wet season and respiratory disease peaked in the cool-dry season. However, no significant seasonal pattern was observed for the age group 15-44 years. It has been reported that the birth peak and neonatal death peak are in November in Matlab. However, the risk of neonatal mortality is several months, usually during food shortage period, before the birth peak (Becker 1981; Becker and Weng 1998).

Moore and colleagues, in an analysis of data from rural Gambia, found that birth during the "hungry season" (July-December) increased the susceptibility of young adults to infectious diseases, possibly through an adverse effect on immune system. The same authors performed a similar analysis in Matlab but did not find such an association of birth and young adulthood mortality (Moore et al. 2004).

A recent study from Burkino Faso, a West African country, examined 4098 deaths during the period of 1993 and 2001 to study the seasonality of death and the effect of seasonality of birth on mortality (Kynast-Wolf et al. 2006). The study found a consistently higher peak of death in the dry season for all age groups except infants, where a peak was observed at the end of the rainy season. This peak of infant deaths was explained by the effect of malaria in the end of rainy season. The study did not find any effect of month of birth on mortality except for infants born in September, October and December who had a higher rate of mortality. In the contrast, Jaffar and colleagues found no significant difference between children born in the dry season and those born in the wet season in a Gambian study (Jaffar et al. 1997).

In summary, deaths exhibit seasonality, varying by region and cause over time. This kind of information could be important for developing locally appropriate interventions for reducing mortality.

Newborn care seeking

Few studies have looked at the role of care seeking in neonatal mortality. Mercer and colleagues in their nationwide case control study in Bangladesh found that 70% of deceased neonates had not been taken to any health care provider, or had been taken to a traditional care provider only. Surviving neonates who were controls in the study had a similarly high proportion (52%) for whom either no care or traditional health care only had been sought. The adjusted odds ratios for these risk factors were: 2.9 for use of a traditional healer for a sick newborn and 23.3 for care not being sought at all (Mercer, Haseen et al. 2006).

2.9.3 Other risk factors

Arsenic contamination of drinking water

Recently, geologic arsenic contamination of underground water has become a major public health issue in Bangladesh and the neighbouring West Bengal state in India (Samuel 2007). The possible contribution of such arsenic-contaminated drinking water to infant mortality was assessed through a recent cohort study in Matlab, Bangladesh (Rahman et al. 2007). The study found that pregnant women drinking tube well water with an arsenic concentration more than 50 µg per litre had a 14% greater risk of foetal loss (relative risk 1.14; 95% CI: 1.04-1.25), and a 17% greater risk of infant death (relative risk 1.17; 95% CI: 1.03-1.32). They also found a significant dose-response relationship of arsenic exposure to the risk of infant death ($p<0.02$). The study authors recommended arsenic mitigation activities for women of reproductive age in order to reduce neonatal and infant death where drinking water was contaminated with arsenic. However, this recommendation may be somewhat premature as a major limitation of the study was that it did not correlate mortality risks with biological arsenic concentrations in either mother or infant.

Poverty

Poverty contributes to neonatal death either through increasing the prevalence of risk factors such as poor maternal nutrition and infection or through reducing access to health care. The Neonatal Survival Steering Team analysed demographic health survey (DHS) data from 20 African and three south Asian countries to examine the relationship between poverty and neonatal mortality (Lawn, Cousens, and Zupan 2005) Although disparity is wider for post neonatal mortality between the richest and poorest household quintiles, they found a consistently higher NMR for households in the lowest quintile compared to the highest quintile. They estimated that if the NMR of the richest section of population could be applied to the entire population of the country, the NMR could be reduced by 19% in 20 African countries, 28% in Bangladesh, 41% in India and 43% in Nepal. This reduction in NMR would prevent an estimated 0.5 million neonatal death in three Asian countries and 219,000 death in African countries. A recent study from Matlab, Bangladesh found substantial socio-economic inequalities in the use of skilled attendants at birth delivery both at home and in the clinic setting, with the difference between rich and poor being greater at the clinic setting (Chowdhury et al. 2006). A study from Leon, Nicaragua also reported that poverty, and social inequities were independently associated with increased risk of infant mortality. The study also found that female education was associated with lower infant mortality in poor households. The authors concluded that female education may contribute to preventing infant mortality in low income countries (Pena, Wall, and Persson 2000).

The relationship between poverty and neonatal mortality is not unique to developing countries. A Canadian study revealed significant disparities in stillbirths and NMR between the poorest and richest sections of the population, which has persisted for the last 20 years (Zhong-Cheng et al. 2004).

Domestic violence

Women experience domestic violence by their husbands or intimate partners both in the developing and developed countries. However, data on the effect of such violence on perinatal and neonatal mortality is limited. Recently a large population-based study from north India showed that one in five women experienced domestic violence by their husband during pregnancy (Ahmed, Koenig, and Stephenson 2006). The study also found that women who experienced physical violence were more than two times more likely to experience a perinatal (hazard ratio 2.59; 95% CI: 1.35-4.95) or neonatal death (hazard ratio 2.37; 95% CI: 1.21-4.62) compared with women who had not experienced violence. Women who experienced violence during pregnancy also had a significantly lower uptake of antenatal care. Although the effects have been argued to be physiological, the pathway of such effects on perinatal and neonatal mortality is not precisely clear from the study.

A recent analysis of Bangladesh health and demographic survey 2004 shows that intimate partner violence (75.6%) is extremely prevalent in Bangladesh and it was more common among Muslim, poor and less educated women (Silverman et al. 2007). Women experiencing violence from husbands were highly likely to report unwanted pregnancies and a pregnancy loss (miscarriage, induced abortion or still birth). Another recent study documented increased risk of child mortality among daughters of educated mothers who had exposed to severe physical violence (Asling-Monemi, Tabassum Naved, and Persson 2008). Although the pathway of such effects is yet to be known, these findings highlight the need to incorporate measures to raise public awareness about the far-reaching consequences of domestic violence.

2.10 Maternal and Neonatal Health Care Seeking

Understanding care seeking patterns, including determinants of maternal and neonatal care seeking, can help in designing and implementing effective public health interventions for neonatal care. In particular, information about care seeking during fatal illnesses can provide valuable clues about potentially harmful behaviours that could be targeted in future programmes. Both maternal and neonatal care practices play important roles in improving neonatal survival.

The Lancet Neonatal Survival Steering team analysed data from 192 countries including 47 demographic health survey datasets (Knippenberg et al. 2005). It found that an optimal maternal care setting that is characterized by high coverage of skilled attendance, institutional delivery and antenatal care led to low levels of neonatal mortality (see Table 2-5). However, factors such as access, human resources and supplies, quality of care, affordability, acceptability, compliance, and knowledge and community involvement may limit the provision and coverage of maternal health care. These factors vary between settings among countries, and even within the same countries (Knippenberg et al. 2005).

Table 2-5. Variation in health system coverage and capacity and functioning across settings with different NMRs (based on 192 countries)

	Neonatal mortality rate (NMR) setting			
	NMR>45	**NMR 30-45**	**NMR 15-29**	**NMR<15**
Global neonatal death (%)	30%	45%	20%	5%
Place of birth	Mainly home	Mix of home and health facility	Most in health facility	Almost exclusively in health facility
(median % births in health facility)	(33%)	(48%)	(65%)	(98%)
Service delivery situation				
Clinical	<30% skilled attendance (median 41%) Limited emergency obstetric and neonatal care	30-60% skilled attendance (median 50%) Moderate coverage, but poor access and affordability	61-95% skilled attendance (median 85%) Moderate to high coverage, but inequities exist and quality is variable, especially for more complex care	90% skilled attendance (median 99%) Universal coverage and increasing coverage with intensive care
Outreach	Limited coverage with antenatal care (median 66%), little postnatal care	Moderate to high coverage of antenatal care (median 77%)	High coverage (median 82%) but quality might be uneven; inequities remain	High coverage (median 98%) and reliable quality

	Neonatal mortality rate (NMR) setting			
	NMR>45	**NMR 30-45**	**NMR 15-29**	**NMR<15**
Community	Traditional birth attendants or no attendants. Other cades of community health /nutrition workers might exist but usually not trained in neonatal care. Lack of community – based organization Unsafe traditional practices might be common	Traditional birth attendants, Community health/nutrition workers, or auxiliary midwives available, but might not be optimally involved in neonatal care Weak community-based organization Unsafe traditional practices less common	Community health/nutrition workers, through birth attendants, and auxiliary midwives work as partners/facilitators Strong community-based organization	Health visitors and others home-based health promoters Unhealthy individual behaviours might be prevalent (e.g. smoking)

Source:(Knippenberg et al. 2005)

The few published studies on care seeking for neonatal illnesses in Bangladesh have been limited mostly to non-fatal illness episodes. The Bangladeshi studies on care seeking during non-fatal illness episodes reveal some common behaviour. For example, families in rural areas prefer to keep their babies inside the home during the first 40 days of life, even when they are ill (Afsana and Rashid 2000; Winch et al. 2005). A recent cross-sectional study from three districts of Bangladesh assessed the birth and neonatal-care practices during delivery and postpartum period. The study interviewed 6785 women who had delivered a newborn infant and found that around 54% of birth attendants washed their hands with soap, and used boiling water to sterilise thread and blades for cutting and tying the umbilical cord. About 44% of newborns were bathed immediately after delivery, and 42% were given colostrum as their first food. The study findings suggest that newborn-care practices during delivery and postnatal period can still be improved upon through behaviour change communication practice (Barnett et al. 2006).

Darmstadt and colleagues conducted a review on domiciliary maternal and newborn care practices in Bangladesh, and reported various factors/practices which are harmful to neonatal health (Darmstadt, Syed et al. 2006). Major harmful practices included: various dietary restrictions for women during pregnancy and the early postpartum period that nutritionally deprived the mother and newborn; culturally mandated seclusion of women during the early postpartum period which limited health care seeking; preference for home delivery which limited skilled birth attendance; application of crude methods such as abdominal massage for speedy birth delivery; practices such as squeezing abdomen or manual removal for speedy delivery of placenta; resuscitation of asphyxiated newborns by manipulating placenta; harmful cord care such as use of bamboo/unsterilised blade for cutting the cord and applying harmful materials to the cord; failure to manage hypothermia such as keeping the newborn on the ground until the placenta was born; and inappropriate feeding such as prelacteal feedings and early introduction of supplemental foods. In addition, knowledge, physical and social insecurity, economic insecurity and environmental insecurities were commonly cited reasons for not seeking health care during the post partum period.

In an earlier cross-sectional survey on care seeking for neonatal illness in four rural sub districts of Bangladesh, 49% of the neonates were reported to have suffered from some kind of illnesses (Ahmed et al. 2001). While 87% of the sick neonates were taken to a provider for care, these consisted mostly of unqualified or non-biomedical providers. Homeopaths (38%) and village doctors (30%) were the most common providers utilised. Only 17% were taken to a trained biomedical or allopathic health care provider, including 5% who were taken to government health facilities. Some neonates were taken to more than one provider. A number of socio-demographic variables were associated with seeking care from a trained provider. These included male sex of the neonate, higher birth order, relatively higher paternal literacy and income level, and antenatal care attendance by the mother.

Another study conducted during 2002-3 in two rural areas of Bangladesh found that while mothers were generally aware of the danger signs of neonatal illnesses, particularly pneumonia and diarrhoea, they were less aware of asphyxia and hypothermia as causes of neonatal death (Winch et al. 2005). There were also some traditional neonatal care practices that had questionable or harmful value. These included bathing the baby after cutting the cord, dietary practices, sleeping on a mat on the floor and massaging the baby with mustard oil.

An earlier study carried out in Matlab examined the utilization of health services during the fatal neonatal illness episodes. The researchers investigated 933 neonatal deaths, and reported health service utilization data by type of providers. Overall, 2.9% neonates received treatment from licensed practitioners, but the intensity of such treatment was more in the MCH-FP project area, and for male neonates. Around 44% received no care at all, with the proportion of no treatment being higher for non-MCH-FP project and female neonates (Bhatia 1989).

Skilled attendance during childbirth and the postnatal care is crucial because of its significant role in preventing neonatal death. Progress in ensuring skilled attendance at delivery is disappointingly slow in Bangladesh. A recent national survey found that the rate of skilled birth attendance had increased to only 13% in 2004 compared to 9% in 1993-94 (National Institute of Population Research and Training (NIPORT) et al. 2003; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). The survey also reported that while 12% of the newborns received care from a trained provider within two days of births, 83% received no care within 42 days of birth (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005).

A recent case control study described and compared care seeking patterns between cases (118 singleton births that had died within 28 days of life) with 71 neighbourhood controls consisting of live births that had survived beyond 28 days of birth (Mercer, Haseen et al. 2006). The study also examined the relationship between patterns of care seeking and the risk of neonatal death. While in 74% of cases, mothers reported that they knew what to do when a neonate was seriously sick, this figure was around 99% for control mothers. With regards to decision making, the husband was mentioned as the principal decision maker during health care seeking for seriously ill neonates in 44% of cases and 70% of neighbourhood controls. Medically qualified providers were the first option of care in 31% of cases and 48% of neighbourhood controls. Around 30% of cases did not seek any care at all compared to 0% in controls.

Care from an unlicensed traditional healer rather than a qualified practitioner was associated with a higher risk of death. The risk of neonatal death was 2.9 times higher, compared to neighbourhood controls, when care was sought from an unlicensed traditional healer rather than a medically qualified practitioner. Not seeking any care was 23 times higher in neonatal death compared to non-neighbourhood control mothers (Mercer, Haseen et al. 2006).

The three-delay model has been used for the systematic assessment of health care seeking to study care seeking during obstetric complications and emergencies. The model comprises three components: delay in recognition of danger signs and symptoms, delay in seeking and accessing care, and delay in the provision of care once at a health facility (Thaddeus and Maine 1994). The model has also been applied to study care seeking for young infants with severe illnesses. Lawn and colleagues (Lawn, Cousens, and Zupan 2005) in their review on neonatal mortality quoted the findings from a study conducted in Guinea. The study in rural Guinea investigated child deaths and found that about 90% of post-neonatal children with pneumonia were taken out for health care, whereas only 60% of newborns with severe infections were taken out for health care. This difference in outside care seeking reflected that delays were more marked for neonatal illness compared to post neonatal illness.

Compliance with referral advice also plays an important role in survival. In a Ugandan study (Peterson et al. 2004) only 21% (15 of 27) of parents of severely ill babies aged 1 week to 2 months complied with referral advice, compared to 31% of parents for children aged 2 months to 5 years (48 of 156). The most common reasons for not following referral advice were lack of money (90%), transport problems (26%) and responsibilities at home (17%). Other impediments included the perception that hospital services are of poor quality, absence of husband who usually made decisions about care seeking, and the child improving after earlier first treatment. The authors underscore the need to consider the interface between the primary-care facility and care at the referral facility to reduce child mortality. First facility level workers should be empowered to treat seriously sick children when the referral was difficult, as recommended in the guidelines for the WHO/UNICEF supported Integrated Management of Childhood Illness (IMCI) care strategy (WHO 2001).

A recent study from Bangladesh reported a significant increase in compliance after referral to hospital treatment or to a qualified doctor (Bari et al. 2006). The programme included activities such as educating families about the danger signs of neonatal illnesses and identifying sick newborns during surveillance for referral to hospital. The study also reported a comparison of factors that enabled families to use hospitals, and the factors that were affecting non-compliance with referrals. Most cited that their reasons for compliance included availability of treatment (65.5%), high quality treatment at local hospital (34.5%), treatment free of charge (21.4%), and hospital being near to home (2.4%). Reasons for non-compliance were; no one was available to accompany the mother to the health facility (24.7%), traditional treatment was provided (19%), bad weather/political strikes (18%), and that the family disliked hospital treatment (12%). An increased trend was also observed for care seeking from qualified doctors in the project area. The generalizability of the factors affecting the compliance of care seeking and adherence to hospital treatment may be limited from such research focussed investigations (Bari et al. 2006).

2.11 What is Verbal Autopsy?

VA refers to the elicitation of the cause of death by interviewing close family members about the events surrounding the fatal illness episode. The interview attempts to unearth what happened during the hours, days, or months preceding death. A "most likely" biomedical cause of death is then inferred from the sequences and combination of symptoms and events reported (Fantahun et al. 2006; Fauveau 2006; Fauveau et al. 1991; Freeman et al. 2005).

Cause of death data is used to study trends in cause-specific mortality fractions (CSMF) between different groups or to evaluate the impact of interventions. Documentation of cause of death is also important in planning public health programmes in order to identify priorities and appropriate interventions (Murray and Lopez 1997). Cause of death data is available in developed countries, where death generally occurs in a medical environment, and autopsies are feasible, widely accepted and often required by law. In developing countries, however, almost all deaths occur outside the health care setting with limited or no medical attendance, and autopsies are rarely carried out. The documentation of cause of death in such cases needs to rely on an alternative source of information that is the description of events preceding death by a close family member who was present during the illness episode.

The concept of VA was first put forward by Biraud in 1956 (Fauveau 2006). It was further developed and systematized, using a list of causes of death that could be ascertained through lay reporting of symptoms preceding death (WHO 1978; Fauveau et al. 1991; Bairagi et al. 1994).

In spite of its obvious advantages, VA-based assessment also has some limitations (Kalter et al. 1990, 1991; Kalter et al. 1999; Snow, Armstrong, and al 1992; Fauveau et al. 1991; Quigley, Armstrong Schellenberg, and Snow 1996; Garenne and Fauveau 2006). These include:

1) The symptom-based assessment of cause of death is culture-specific, and hence requires formative work to unearth local perceptions of health and disease.

2) VA requires validation, and this is difficult given that medical autopsy is the gold standard for ascertaining biomedical cause of death.

3) VA is useful only for certain categories of death that have distinctive signs and symptoms that can be easy to assess.

4) The VA method is subject to recall bias which can vary across the different techniques for assigning cause of death. This limits the comparison of VA assigned cause of death across different countries.

2.11.1 Evolution of VA at Matlab

The Matlab HDSS has been collecting cause of death information since 1966. Prior to 1986, data was collected by lay reporters who chose a cause from a set list. There was no system for medical assessment and checking (Zimicki et al. 1985). In 1986, the death form was modified to collect more specific information on signs and symptoms prior to death. This VA tool, the one-page Death Form, was used for death across all ages. The Death Form consisted of three parts: identification of the deceased, signs and symptoms prior to death, and medical consultations prior to death. A group of non-medical staff members, with at least 10 years of school education, was trained to record timing, duration, and gradation of reported symptoms preceding death. A medical assistant, with three years of medical education, reviewed the Forms to assign a possible cause of death using ICD-9 codes (Fauveau et al. 1991). However, the lack of a detailed structured checklist for collecting information as well as the lack of a comparison or validation study for medical assistant assessment limited the utility of the tool.

2.11.2 Limitations in VA Method at Matlab prior to 2003

There were a number of limitations with the VA method that was being used prior to 2003 in Matlab:

1. A large proportion of neonatal deaths in the Matlab HDSS area were unclassified due to inadequate information regarding causes of death. There were a number of reasons for this, primarily the difficulty in assigning common causes of early

neonatal death such as sepsis and birth asphyxia for which there are no specific signs and symptoms. Another reason was the difficulty for interviewers, with non-medical backgrounds, to elicit relevant information using only open-ended questions.
2. Questions relating to pregnancy and childbirth were not structured.
3. There was inadequate elicitation of health care seeking behaviour during the fatal illness episode.
4. A medical assistant was engaged without any comparative or validation study for assigning cause of death.

In order to improve the VA method, the Matlab HDSS introduced a new VA questionnaire specially designed for neonates, which involved reviews by both a physician and a medical assistant in 2003. The information collected since 2003 provides the opportunity to analyse a reliable and complete dataset on the patterns, causes, and associated factors of neonatal death in intervention and comparison areas, and to evaluate alternative methods for assigning cause of death.

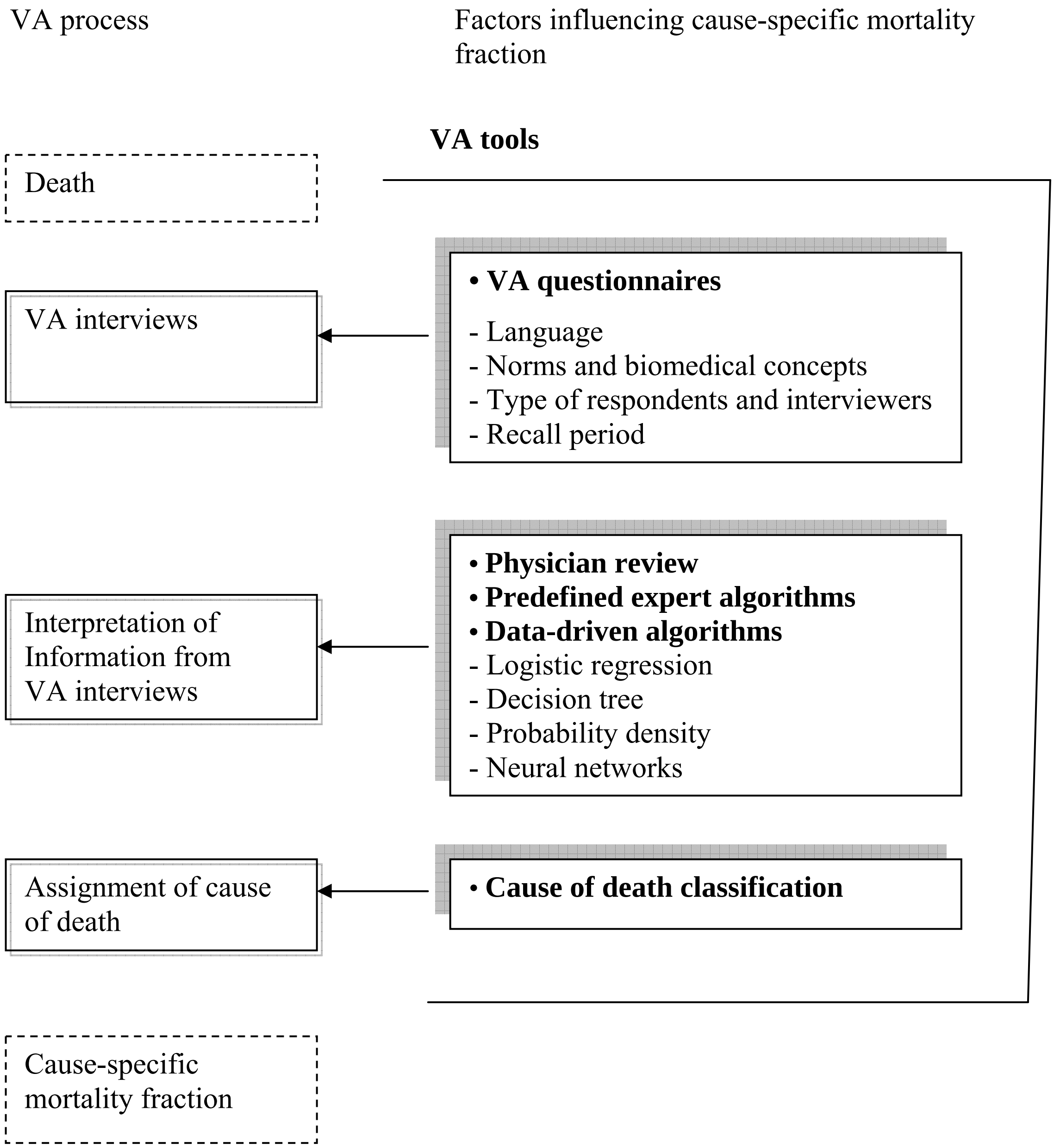
2.11.3 Factors influencing VA-based causes of death

Typically a standard VA tool consists of a questionnaire, cause of death classification system, and diagnostic guidelines/criteria for assigning cause of death. These core components of the VA tool and several operational factors related to collecting and collating of VA data can influence the reliability and validity of the causes determined, and can limit international comparisons. The most common factors that can influence VA-based assessment are shown in the diagram (See Figure 2-5).

<u>Interviewers</u>

While both medically qualified and non-medical interviewers can collect information through VA, there are pros and cons in using these two groups with regards to the validity of VA-based data. One school of opinion believes that medically trained interviewers are knowledgeable, and as such can probe and determine the signs and symptoms of the deceased from the caregivers (Huong, Minh, and Byass 2003). Another group believes that medical knowledge may bias data collection, and the results can be biased towards certain diseases familiar to the interviewers. In the context of this debate, several studies have suggested that a well-trained non-medical person can obtain accurate information using appropriate questionnaires (Kahn et al. 2000; Kalter et al. 1990).

Like other questionnaire surveys, it is highly likely that there are variations in the data validity between different VA interviews (Fauveau et al. 1991; Huong, Minh, and Byass 2003). Hence, it may be preferable to employ an interviewer from the local community, after standardizing the training and other characteristics of interviewers.



Source: (Soleman, Chandramohan, and Shibuya 2006)

Figure 2-5. VA process and factors influencing cause-specific mortality fractions

2.11.4 Respondents

Optimum respondent characteristics are likely to improve the quality of VA interviews. Although the criteria for an optimum respondent and the ways to identify them have not been formalised, studies suggest that the accuracy of VA data improves if the respondent was a caretaker of the deceased during the fatal illness episode. There is little published information about the effect of the respondent's characteristics on the quality of VA data. Experiences from studies suggest that cultural and societal factors should be taken into consideration when selecting respondents. For example, a female respondent is clearly preferable to a male when conducting a survey of maternal mortality or female reproductive health (Huong, Minh, and Byass 2003).

2.11.5 Recall period

Differences in recall period may influence the accuracy of a VA tool. Too long a recall period is likely to affect a respondent's ability to recollect relevant information, while too short a recall period may cause emotional distress to the respondents during the VA interview process (Soleman, Chandramohan, and Shibuya 2006) and could be considered unethical.

A validation study using different recall periods ranging from 1 to 21 months found no significant differences in the accuracy of statistics between the time periods (Soleman, Chandramohan, and Shibuya 2006). Several studies have suggested a recall period between 1 to 12 months is generally acceptable for VA interviews (Huong, Minh, and Byass 2003; Mirza et al. 1990).

2.11.6 Language and piloting

Questionnaire characteristics such as language, translation, and contents can influence the collection of reliable VA data from the respondent. Only a few studies have examined the influence of such factors on the validity of VA interviews. Leading VA researchers from developing countries at a WHO meeting had suggested that the questionnaire should be based on local language and concepts, and that preferably multiple translators with a medical background should be involved in developing the VA questionnaire (Soleman, Chandramohan, and Shibuya 2006;

WHO 2005). As language and biomedical concepts differ considerably between cultures, pretesting/piloting has been recommended to gain more insights in local sensitivities, the sequence of questions, language and local biomedical concepts before finalizing the VA questionnaire for actual data collection (Soleman, Chandramohan, and Shibuya 2006; WHO 2005).

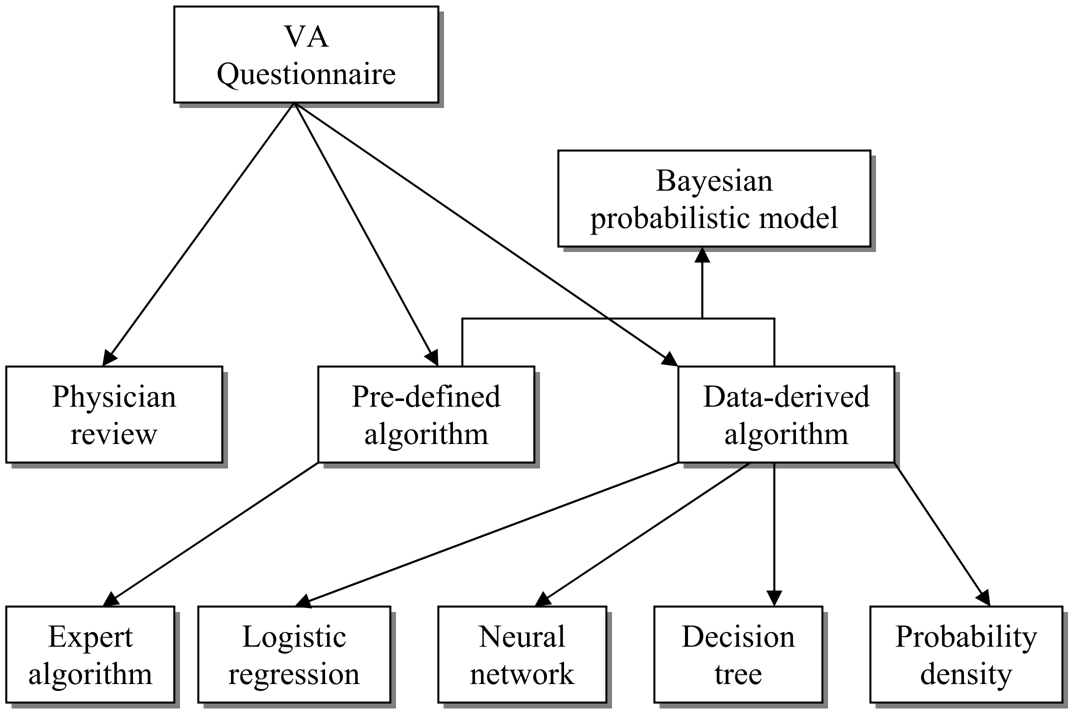
2.11.7 Structure of VA questionnaire

Besides the content, the structure and layout of the questionnaire are helpful considerations in gaining reliable and valid data from VA interviews. A VA tool may be either open-ended or close-ended for recording responses, or a combination of both. However, few studies have examined the effect of open-ended and close-ended questions on the performance of VA. One study in Pakistan examined open-ended questions and a format with combined open and close-ended questions, and found a comparable but slightly higher sensitivity with the combined format for a number of causes of neonatal death (Marsh et al. 2003). Another study in Nepal did not detect any difference between the two formats (Freeman et al. 2005).

There are also considerations with regard to the sequence of questions, respondent fatigue, recall, and recognition, and interviewer skills. A clear layout of questions and questionnaire can help improve the quality of VA data by reducing confusion, increasing compliance of respondents and interviewer, and decreasing coding errors (WHO 2005).

2.12 Methods for Assigning Causes of Death

A number of methods have been used to interpret VA-based interview data to derive causes of death. These are based primarily on either medical review of questionnaires or through predefined expert algorithms or data-derived algorithms (Quigley, Chandramohan, and Rodrigues 1999; Quigley et al. 2000; Freeman et al. 2005; Baqui et al. 1998; WHO 2005). Possible methods for interpretation of VA interviews to derive causes of death are outlined in Figure 2-6.



Source: (Quigley et al. 2000)

Figure 2-6. Methods for assigning cause of death using VA data

2.12.1 Medics/physician review

Internationally, physician review is used widely to derive cause of death from VA data. In this method, one or more physicians review the information on the questionnaire and, using their professional knowledge and experience, assign a probable cause of death.

The main advantages of physician review over computer-based algorithms is that physicians are usually oriented to the epidemiological patterns and characteristics of diseases in their area, and can assess open-ended comments and information about care seeking to assign possible causes of death.

There are however several disadvantages of physician review over algorithms. These include (1) the time consuming and tedious nature of the VA review; (2) the subjective approach with potentially poor repeatability; (3) high cost; (4) the tendency to assign a single cause of death even though multiple causes may be involved; (5) difficulty in sustaining long-term commitment (Byass, Huong, and Minh 2003; Fauveau 2006; Filippi et al. 2006; Snow, Armstrong, and al 1992; Todd et al. 1997; Todd et al. 1994 ; Garenne and Fauveau 2006). These aspects have been summarised by a WHO technical consultation committee on VA tools and are presented in the Table 2-6.

Table 2-6. Strengths and limitations of physician review and expert algorithm for coding VA

Operational issues	Physician review	Expert algorithm (predefined)
Accuracy of cause-specific mortality (CSM) estimates	Validation study suggests that this method gives robust estimates of CSM for common causes	Sensitivity and specificity are less than in physician review; robust estimates of CSM, but need research to apply it
Repeatability of CSM estimates	A study of child VA in Gambia showed poor repeatability of diagnosis reached by a panel of physicians	Very consistent
Human resource requirements	Labour intensive. Needs three +/- 3 physician-years for assessing 3000 VAs annually	75% of physician time can be saved. Needs two data input clerks entering 3000 VAs annually
Logistic requirements	Computer hardware plus software for data management and statistical analysis	Computer hardware plus software for data management and statistical analysis
Sustainability	Difficult to sustain the commitment of physicians over a long period	Data management needs close monitoring and routine maintenance of the system
Time lag between VA interview and diagnosis	Typically the time lag is 3-5 months	Typically 1-2 months
Transparency of the method	Judgement/rules are not transparent	Transparent and clinically credible

Source: (WHO 2005).

2.12.2 Algorithms

An algorithm maps both clinical and laboratory-based diagnostic criteria and helps in the systematic interpretation of VA interview to derive cause of death. It also provides a reliable, consistent and sustainable means for assessing cause of death. The algorithm acts as a checklist of relevant information to be included for the development of an appropriate questionnaire. Algorithms can be developed either based on predefined expert criteria or using various analytic techniques (Soleman, Chandramohan, and Shibuya 2006; WHO 2005).

The major strengths of algorithm-based assessment over physician/medic review are that algorithms provide a systematic interpretation of VA data through an automated process, and thus it has good repeatability. It has the potential to derive causes of death interpreting large numbers of VA interviews in a short period of time, so it is both time-saving and cost-effective. The use of standardised validated algorithms improves the comparability of causes of death across sites both locally and internationally.

However, there are disadvantages of the algorithm approach over physician review. These include its (1) inability to discriminate between non-specific features of fatal illnesses, leading to identification of multiple causes of death; (2) inability to take into account the local epidemiological profile of diseases when interpreting VA data; (3) inability to process open-ended responses in VA data. These characteristics have been further summarized by a WHO technical consultation committee on VA tools and are also presented in the Table 2-6.

Expert algorithm

Expert algorithms are based on symptoms deemed by physicians to be essential, confirmatory, or supportive in diagnosing a particular cause of death. These symptoms, however, are not necessarily the most discriminating ones. The algorithm is developed on a set of predefined criteria, so it overcomes the subjectivity of physician review which has been criticized. As it is applied through an automated process, it is also a time effective approach.

There is some concern about the predefined criteria used in expert algorithms, as the criteria can include symptoms that cannot discriminate between conditions presenting with similar clinical features. For example, birth asphyxia and other neonatal problems manifest with several common symptoms; fever is a cardinal feature of both malaria and pneumonia (Byass et al. 2006; Byass, Huong, and Minh 2003; Fantahun et al. 2006; Kalter et al. 1990; Kalter et al. 1999; Mobley et al. 1996; Quigley, Armstrong Schellenberg, and Snow 1996).

Data-derived algorithms

As the name signifies, data-derived algorithms use statistical techniques to identify a set of symptoms/signs derived from VA data that optimally predict mortality. Scores are then summed and assessed to derive a cause of death (COD) using a locally validated cut-off score for a particular cause. These data-derived methods are considered a potential alternative method to deriving a cause of death.

There are several analytic techniques to identify data-derived algorithms, which are based on linear and discriminatory techniques (logistic regression), probability density estimation, and decision tree and rule-based method (artificial neural networks). Possible data-derived algorithms are shown in the Figure 2-6. There are advantages and disadvantages of data-derived algorithms. Data-derived algorithms can be applied quickly and easily, and are repeatable and sustainable. Quigley and colleagues (Quigley, Chandramohan, and Rodrigues 1999) in their validation studies in Tanzania found a similar cause-specific mortality fraction between algorithm and physician review for data-derived algorithms for injuries, TB/AIDS, meningitis and diarrhoeal diseases, although some adjustment may be required for selecting a cut-off score.

Byass and colleagues applied a Bayesian probabilistic approach, a combination of expert algorithm and a data derived approach, in interpreting VA interview and compared their findings with physician review. Using 189 cases, they found an agreement of 70% between a probabilistic approach and the physician-agreed cause of death. The authors revised the previous model and included 104 indicators and 34 possible causes of death. The same 189 samples were used in the revised models and an overall 89.9% agreement was reached. The authors concluded that probabilistic approach could be an alternative to physician review for interpreting VA data (Byass et al. 2006; Byass, Huong, and Minh 2003).

There are however several disadvantages of using data-derived methods to derive a cause of death: 1) a relatively poor sensitivity and specificity for illnesses with non-specific symptoms 2) the need for adjustments to algorithms and cut-off scores when used in new geographic areas 3) an inability to use information from open-ended responses 4) a small sample size as a limiting factor for the algorithm approach which is not a consideration in physician reviews (Boulle, Chandramohan, and Weller 2001; Byass et al. 2006; Byass, Huong, and Minh 2003; Quigley, Chandramohan, and Rodrigues 1999; Quigley et al. 2000).

The advantages and limitations of different forms of algorithms are further summarized by a WHO technical consultation committee on VA tools (WHO 2005) and are presented on the next page (see Table 2-7).

Table 2-7. Strengths and limitations of data derived algorithm for coding VA

	Data derived algorithm	
Operational issues	***Logistic regression derived***	***Artificial neural Network***
Accuracy of cause-specific mortality (CSM) estimates	Sensitivity and specificity of this method is less than physician review; provides robust estimates of CSM	Accuracy comparable to physician review; further development needed.
Repeatability of CSM estimates	Highly consistent	Highly consistent
Human resource requirements	75% of physician time can be saved. Needs 2 data input clerks to enter 3000 VAs annually	80% of physician time can be saved. Needs 2 data input clerks to enter 3000 VAs annually
Logistics	Computer hardware plus software for data management and statistical analysis	Need to develop customized neural network systems
Sustainability	Data management needs close monitoring and routine maintenance of the system	Data management needs close monitoring and routine maintenance of the system
Time lag between VA interview and diagnosis	Typically 1-2 months	Typically 1-2 months
Transparency of the method	Transparent, but some criteria may lack clinical credibility	Not transparent; clinical credibility may not be known

Source: (WHO 2005).

2.13 Validation of Verbal Autopsy

The term validity refers to the degree to which a test value approaches the gold standard value. The accuracy of causes ascertained by the VA method has been validated by comparing with standard medical methods of ascertaining causes. It has been found to be particularly accurate in identifying distinctive syndromes such as neonatal tetanus, measles and injuries, while accuracy has been only moderate for diarrhoea and pneumonia (Kalter et al. 1990, 1991; Kalter et al. 1999; Marsh et al. 2003; Snow, Armstrong, and al 1992). The validity of the VA-based causes of death is also affected by the cause and characteristics of the disease in question, and several other methodological aspects such as the cause of death classification process, methods for assigning cause of death, the design and method of the questionnaire, field procedures and sample size (Chandramohan et al. 1994; Soleman, Chandramohan, and Shibuya 2006). Current experience with validation of VA methods in developing countries is presented in the next sub-section.

2.13.1 Validation studies from developing countries

The few studies in developing countries validating VA methods to diagnose causes of neonatal mortality have generally found a high level of accuracy of these methods for a number of common conditions, while for other conditions they did not yield very good results.

In a study in Karachi, Pakistan, caregivers of 137 neonates who had died in a hospital during 1993-4 were interviewed at home after a median of 75 days (range 3-230 days) using a combined verbatim and structured VA questionnaire. For all neonatal death cases, a hospital-based cause of death was assigned by a panel of physicians using a strict case definition. Similarly, a separate group of physicians reviewed VA interviews and assigned a cause of death based on a predetermined scoring system. Results from the VA were compared to the hospital-derived main causes.

The study found that VA identified at least one diagnosis accurately in 71% of the newborns. Sensitivity was reasonably high for neonatal tetanus (84%), and for too early/too small syndrome (90%) which included low birth weight, prematurity and small for gestational age categories of cases. Sensitivity was higher for prematurity (71%) than for birth asphyxia (58%), infections (39%) and low birth weight (42%) alone. Generally most diagnoses had high specificity (67-99%), but positive predictive values ranged from a low of 19% for small for gestational age to the highest of 94% for neonatal tetanus. The study concluded that VA-based diagnoses, especially tetanus and too small/too early syndrome were appropriate for targeting for intervention (Marsh et al. 2003).

In Bangladesh, Kalter and colleagues evaluated the validity of retrospective interviews with caregivers for diagnosing major neonatal illnesses and cause of death among neonates (Kalter et al. 1999). The study was carried out in two hospitals at Dhaka from where a convenience sample of 149 neonates with common illnesses was enrolled. Hospital-based diagnoses were compared to the diagnoses derived from interviews with the caregivers of the neonates at their homes. For the latter diagnoses, a set of expert algorithms was constructed based on combinations of signs reported by the caregivers. The authors found a high sensitivity of algorithms (more than 80%) for neonatal tetanus, low birth weight/severe malnutrition and prematurity. The study documented a high specificity (more than 80%) of the algorithm for pneumonia and birth asphyxia. The study concluded that retrospective caregivers' interviews were a valid means for diagnosing common neonatal illnesses in a setting with limited health care facilities.

A much larger prospective study in Tanzania involving 629 perinatal and neonatal deaths (Setel, Whiting et al. 2006) was conducted to validate VA-based diagnoses. One group of physicians reviewed the VA information, and the other group reviewed the medical records (MR), and assigned cause of death using ICD-10 codes. Medical record-based diagnoses were scored for uncertainty, and sensitivity and specificity adjusted. The cause-specific mortality fraction (CSMF) is the number of deaths due to a cause divided by the total number of deaths in that age group. The validity of VA-based diagnoses was assessed against MR-based diagnoses using CSMF, sensitivity, specificity and positive predictive values (PPV).
Of the neonatal death, VA reasonably estimated the CSMF for pneumonia and birth asphyxia as reflected by a minimum difference between $CSMF_{VA}$ and $CSMF_{MR}$

scores (0.00-0.01). Sensitivity, specificity and PPV for birth asphyxia were 0.54, 0.93 and 0.38 respectively. Sensitivity and specificity for other causes included 61% and 84% for stillbirths, 64% and 97% for prematurity/low birth weight, and 51% and 100% for pneumonia respectively. Sensitivity was very poor for bacterial sepsis (6%), although the specificity was 100%. Specificity is more important when CSMF is small as a measure of validity. The study concluded that VA could reliably estimate major causes of neonatal death of public health importance.

In Kenya, a prospective study (Snow, Armstrong, et al 1992) validated VA-based cause of death (derived by a panel of physicians) of 303 under-five child deaths (86 neonates and 217 post-neonates) by comparing medically confirmed diagnoses in a district hospital during 1989-1991. Neonatal deaths were investigated for sepsis and tetanus separately. While specificities were greater than 80% for common causes of death, sensitivities were greater than 75% only for measles, neonatal tetanus, malnutrition and trauma-related death. The sensitivity for neonatal sepsis was 61% only. The sensitivities of VA were below 50% for malaria, anaemia, acute respiratory infections, diarrhoea and meningitis. The authors concluded that VA performed well for illnesses with a clear and unambiguous syndrome of signs and symptoms.

Using data from the same Kenyan hospital as used by Snow and et al, Quigley et al validated expert algorithm and data-derived algorithms for diagnosing causes of death by comparing medically conformed diagnoses of 295 post-neonatal deaths (Quigley, Armstrong Schellenberg, and Snow 1996). Data derived algorithms (using logistic regression) and expert algorithms produced similar levels of sensitivity and specificity except for malaria where data-derived algorithm produced higher sensitivity (71%) than expert algorithm (47%). Both expert and data derived algorithms had a relatively poor sensitivity for respiratory tract infections and meningitis.

In Namibia, Mobley et al obtained the clinical records of 135 children who died in the hospital and validated VA-based major causes of death (derived by using several expert algorithms) by comparing with medically confirmed hospital diagnoses (Mobley et al. 1996). The 243 diagnoses were generated from 135 cases and included malnutrition (77), diarrhoea (73), pneumonia (36), malaria (35) and measles (24). The sensitivity was the lowest for malaria at 45% and highest for diarrhoea at 89%, while the specificity was lowest for diarrhoea at 61% and highest for malaria at 87% among the five major causes of death. The study suggested that VA could be used for assessing major causes of death, but may have limitations in programme evaluations.

In South Africa, Kahn et al validated physician review for interpreting VA interviews for assigning causes of death by comparing medically confirmed hospital diagnoses (Kahn et al. 2000). They used a single VA tool to investigate deaths in both under-five children and adults 15 years and older. The study included 33 children and 89 adults. Among children, the sensitivity and specificity for communicable diseases was 69% and 95%, for non-communicable diseases it was 75% and 91%, and for accident or violence was at 100% and 97% respectively. The corresponding sensitivity and specificity among adults was 89% and 93% for communicable diseases, 64% and 50% for non-communicable diseases, and 75% and 98% for accident or violence respectively. The study concluded that a single VA can be used for reliably classifying cause of death in both adults and children.

None of the above studies used a standardised format for questionnaires, categories of causes of death, study design or algorithm for determining cause of death. These differences limited the validity, reliability and comparison of causes of death between settings and countries. However, despite these differences some common findings enable conclusions to be drawn. VA was more effective for diagnosing certain causes of death which had distinctive clinical features such as tetanus, malnutrition, measles and injuries/accident-related death. The sensitivity and specificity of diarrhoea presented a mixed picture from low to high, and varied depending upon the criteria used for assigning cause of death. The sensitivity and specificity of pneumonia and malaria also varied widely because of overlapping signs and symptoms. None of the studies used triangulation of methods for diagnosing causes of death interpreting same VA information.

2.13.2 Comparison of methods for interpreting same VA interviews

As stated before, an appropriate validated method is required for interpreting VA interviews to allocate a cause of death. The validity of using medical review for allocating cause of death has long been established, using hospital-based diagnoses as the gold standard. However, in the poor health care setting of developing countries, inadequate clinical history and record keeping at the health facility level often limit a hospital-based diagnosis. Again documentation and accuracy of causes of death in death certificates are of poor quality in many developing countries (Moyo et al. 2007). Therefore, VA is widely accepted for collecting information on causes, while physician review is often used for assigning causes of death.

As physicians are often scarce in rural areas, it is important to compare alternative methods such as review by medical assistants and computer-based algorithms for assigning cause of death. There is no published data on their comparative value, except for one study in Nepal which compared physician review with computer algorithms (Freeman et al. 2005).

Freeman and colleagues examined and compared the agreement/reliability between VA-based neonatal causes of death assigned by physicians and computer-based algorithms. The study was conducted in a rural district of Nepal between 1998 and 2001, and included 167 neonatal deaths for analysis. The VA contained standard structured questions as well as open-ended questions on illness description and events leading to death. Physicians assigned one or more cause in 59% cases, with the remaining 41% classified as uncertain, while the algorithm could assign a cause in 89% of cases. The study found good agreement as measured by kappa scores between physician reviews and algorithm-based cause of death for diarrhoea (0.81), prematurity (0.73) and acute respiratory infection (0.56). There was poor agreement for birth asphyxia (0.17), sepsis (0.02), and neonatal tetanus (0.10).

In conclusion, algorithms could assign multiple causes in 58% cases compared to 11% among physicians. The authors have suggested that in the absence of a gold standard, a combination of physician review and computer-based algorithm could be used for assigning cause of death (Freeman et al. 2005).

A recent study from Ethiopia evaluated the performance of a new computer-based model "Inter-VA method" for diagnosing age-specific cause of death by comparing physician interpretation of the same VA interviews (Fantahun et al. 2006). The InterVA method is based on probabilistic (Bayesian theorem) approach and requires a set of indicators such as signs and symptoms and history circumstances as the inputs to the computer, which produce possible causes of death along with their likelihoods when the computer is model run. Cause-specific mortality fraction (CSMF) was used to measure the performance of the model. A total of 289 VA interviews were completed consisting of 48 infants, 101 children (1-14 years) and 140 adults. Among the infant deaths, prematurity/low birth weight, sepsis/pneumonia and perinatal deaths accounted 80% of deaths both by InterVA and physician assessment. Among all deaths, pneumonia/sepsis, pulmonary tuberculosis, malaria, and diarrhoeal disease/malnutrition accounted for more than 60% of deaths. The authors concluded that this method was reliable and less labour intensive for classifying causes of death both for rural and urban settings and for different age groups. The method is likely to overcome the concerns associated with expert assessment and the limitations with the algorithm approach. However, it needs to be evaluated in different settings with different mortality patterns prior to its wider use.

A recent study from South Africa compared the immediate causes of death on death certificates with those obtained by clinical record review combined with VA. The study included 177 child deaths from three rural municipalities including 35 neonatal deaths. Pneumonia, gastroenteritis and septicaemia were the top three causes of death by both the methods. Sudden, unexplained and ill-defined causes of death were among the top causes of death in combined VA and clinical record reviews, while tuberculosis and natural cause of death were top causes on the death certificates. In 47% cases of death there was agreement on immediate cause of death, and when natural and sudden ill defined causes were included agreement increased to 54%. The authors concluded that VA combined with clinical record reviews provided extra information which helped determine more specific diagnoses for deaths certified as natural causes in death certificates and where mortality data is poor (Moyo et al. 2007).

The next sections will briefly review a number of evidence-based interventions for improving perinatal health and survival. While these interventions are not a direct subject of the study, some of these are recognized as part of the health service determinants of neonatal survival. Hence a brief review of these interventions is in order.

2.14 Interventions for Reducing Perinatal and Neonatal Mortality

Poverty, illiteracy, poor social status of women, and a poorly functional health care system are critical underlying factors that adversely affect maternal and child health in many developing countries. Although relatively difficult to change in the short term, addressing these factors is an important long term goal for most developing countries.

Substantial reductions in neonatal death can be achieved through simple and inexpensive interventions, especially if they are appropriately planned and implemented in an integrated manner. An increasing number of pilot, community and hospital-based research projects have demonstrated that three out of four newborn deaths can be averted with low cost management strategies such as appropriate techniques for resuscitation of asphyxiated babies, antibiotics for pneumonia, sterile blades for cutting umbilical cords, maternal tetanus prophylaxis, skilled midwife care, skin-to-skin contact for keeping the baby warm, and breastfeeding (Bhutta et al. 2005; Darmstadt, Bhutta et al. 2005; Bang, Bang, Baitule et al. 2005).

The Lancet Neonatal Survival Steering Team (Darmstadt, Bhutta et al. 2005) has reviewed data on pre-pregnancy, antenatal, intranatal and postnatal interventions from developing countries to identify low cost effective interventions for reducing neonatal mortality. The group identified 16 interventions which were effective in reducing neonatal mortality, as shown in Table 2-8.

Table 2-8. Evidence of efficacy for intervention at different time periods

	Level of evidence	Reduction (%) in all cause neonatal mortality or morbidity/major risk factors (effect range)
Preconception		
Folic acid supplementation	IV*	Incidence of neural tube defects: 72% (42-87%)
Antenatal	V**	33-58%
Tetanus immunization		Incidence of neonatal tetanus: 88-100%
Syphilis screening and treatment	IV	Prevalence dependent
Pre-eclampsia and eclampsia prevention (Calcium supplementation)	IV	Incidence of prematurity 34%: (-1 to 57%) Incidence of low birth weight: 31% (-1 to 53%)
Intermittent presumptive treatment for malaria	IV	32% (-1 to 54%) PMR: 27% (1-47%)(first/second births)
Detection and treatment of asymptomatic bacteriuria		Incidence of prematurity/low birth weight: 40% (20-55%)
Intrapartum		
Antibiotics for preterm premature rupture of membranes	IV	Incidence of infections: 32% (13-47%)
Corticosteroid for preterm labour	IV	40% (25-52%)
Detection and management of breech (caesarean section)	IV	Perinatal/neonatal death: 71% (14-90%)
Labour surveillance (including partograph) for early diagnosis of complications	IV	Early neonatal death: 40%
Clean delivery practices	IV	58-78% Incidence of neonatal tetanus: 55-99%
Postnatal		
Resuscitation of newborn baby	IV	6-42%
Breastfeeding	V	55-87%
Prevention and management of hypothermia	IV	18-42%
Kangaroo mother care (low birth weight infants in health facilities)	IV	Incidence of infections: 51% (7-75%)
Community-based pneumonia case management	V	27% (18-35%)

* IV. Evidence of efficacy. Intervention effective in reducing perinatal or neonatal mortality, or primary determinants therefore, but there is lack a lack of data on effectiveness in large-scale programme conditions

** V. Evidence of efficacy and effectiveness. Interventions of incontrovertible efficacy and which seem feasible for large-scale implementation-based on effectiveness trails

Source: (Darmstadt, Bhutta et al. 2005).

The next section describes intervention studies conducted at different stages of the reproductive cycle which were found to be effective in reducing perinatal and neonatal mortality.

2.15 Interventions Targeted Through Mothers

2.15.1 Maternal education/schooling

Maternal educational level is associated with improved perinatal and neonatal survival. In an earlier observational study conducted in Nigeria, Caldwell and MacDonald demonstrated a close relationship between maternal schooling and infant mortality (Caldwell and McDonald 1982). This relationship has been borne out by a number of further studies. In a review of cause-specific mortality in Brazil, Victoria et al. showed an inverse relationship between mother's schooling and perinatal death (Victoria et al. 1992). Health and Demographic Survey data from 17 countries have also demonstrated a similar link between maternal education and neonatal survival, even after adjusting for socioeconomic factors (Bicego and Ties Boerma 1993).

Although the pathway of improved survival of babies born to educated mothers has not been precisely elucidated, the potential linkages include economic advantages, access to health care, better care seeking behaviour, and appropriate birth spacing for educated mothers.

With evidence of such a strong linkage, building the capacity of mothers through education is a key long term strategy for improving neonatal survival.

2.15.2 Nutrition intervention in pregnancy

Poor maternal nutrition is a huge problem in developing countries, leading to foetal malnutrition, low birth weight, and other adverse pregnancy outcomes such as premature births and stillbirths (de Onis, Blossner, and Villar 1998; Jackson, Bhutta, and Lumbiganon 2003). In turn, low birth weight and premature births lead to increased risks for morbidity and mortality during the perinatal and neonatal periods. Given the link between maternal malnutrition and LBW, there is evidence that interventions to improve maternal nutritional status can improve infant outcomes.

In 1997, Ceesay et al. provided supplemental high-protein energy biscuits (900 calories per day) to rural Gambian pregnant women, and compared the outcomes with a control group which did not receive the supplement. Mothers in both groups also received iron and folate supplements, tetanus toxoid vaccination, and chloroquine for malaria where it was indicated. This randomised controlled trial found a significant increase in the average birth weight (136 gm, $p< 0.001$) and an overall 35% reduction in LBW ($p<0.001$) among infants born to supplemented mothers. More importantly, the study documented a 49% reduction in perinatal death and a 40% reduction in early neonatal death, although no effects were noted on the post-neonatal death rate (Ceesay et al. 1997).

In another study, Prentice and colleagues supplemented Gambian pregnant women from the 16th week of gestation with a peanut-based biscuit and a vitamin fortified tea drink (Prentice et al. 1983). They reported a significant increase of birth weight with a mean of 224g and a decrease in the proportion of LBW in supplemented mothers compared to non-supplemented mothers during the wet season. However, the study did not find any such effect during the dry season when women are usually in a positive nutritional balance. The authors underscored the importance of selective targeting of interventions for risky groups.

A more recent study from rural Bangladesh also evaluated prenatal food supplementation on birth weight and its variation by maternal postpartum weight (Shaheen et al. 2006). In a non-randomised intervention study, women (n=777) were supplemented six days a week for four months starting from early pregnancy with an extra 608 kcal/day. The daily supplement was prepared with locally sourced rice, pulse powder, molasses, and soybean oil. The women also received standard iron and folic acid supplements. There was an increase in the average birth weight by 118gm (1g/day). The effect was highest for births occurring in January and February, corresponding with the period of seasonal food insecurity in Bangladesh. The study also reported a linear dose response relationship between duration of supplementation and birth weight among women who had a median postpartum weight of 42 kg or higher. Such a dose response was not observed among women with a lower postpartum weight (<42kg).

2.15.3 *Micronutrient supplementation during pregnancy*

Maternal anaemia is widespread in developing countries and is often considered as an underlying risk factor for low birth weight. There is evidence that anaemia management during pregnancy, alone or with micronutrient mixtures, could improve maternal anaemia, but there is no conclusive effect of anaemia management on perinatal and neonatal outcomes (Bhutta et al. 2005).

A study in Sri Lanka evaluated the impact of iron and folic acid supplementation (equivalent to 60 mg elemental iron) and fortified food supplementation (thriposha) along with antihelminthics on maternal anaemia, birth weight and perinatal survival (Atukorala et al. 1994). The study reported significantly higher maternal haemoglobin in women who received oral iron supplementation for more than 17 weeks compared with those supplemented for less than 17 weeks. However, the study did not find any effect on maternal weight gain and no significant effect on the birth weight of newborns was observed.

A study from India (Agarwal, Agarwal, and Mishra 1991) reported a reduction in low birth weight rates and an increase in birth weight among women who were supplemented with both iron and folate compared with non-supplemented women. The study also reported that women who were supplemented between 16 and 19 weeks of pregnancy had a higher mean birth weight for their babies compared with women supplemented after 20 weeks.

A recent randomized placebo control trial from India enrolled 200 undernourished pregnant women at 24-32 weeks of gestation (Body Mass Index <18.5 or haemoglobin level between 7-9g/dl) from the antenatal clinic of a hospital in East Delhi, India (Piyush et al. 2007). Women in the micronutrient group received 29 different vitamins and minerals. Both micronutrient and placebo groups received standard doses of folic acid and iron supplement. This study documented an increase of birth weight by 98g, length by 0.80cm and mid arm circumference by 0.20 cm among the newborns in the micronutrient group. The incidence of low birth weight was decreased by 70% and early neonatal morbidity by 58%. Both the reductions were statistically significant.

2.15.4 Maternal immunization and management of infection

A systematic review on interventions from developing countries shows that tetanus immunization during pregnancy and clean delivery is associated with reduced neonatal mortality and morbidity (Bhutta et al. 2005).

2.15.5 Antenatal care

Antenatal care is one of the four main components of the Safe Motherhood Programme, and is being practiced in health care settings (WHO 1994). Antenatal care can help to identify risks for mother and the unborn child, diagnose and manage maternal health problems, provides counselling on breastfeeding, family planning, nutrition and physical activities, and provides an opportunity for micronutrient supplementation and tetanus prophylaxis.

Birth preparedness, recognition of dangers signs during pregnancy and delivery, planning for birth place and attendant, savings, and transport plan in case of emergency are other major components of antenatal counselling for the women and family members.

The routine antenatal care services include physical examination including height and weight checking, measurement of uterine growth, recording blood pressure, monitoring foetal heart sound, performing urine tests for sugar and protein and blood tests to detect syphilis and severe anaemia. Although WHO recommends that a woman should make at least four visits to an antenatal clinic, the content, timing and number of visits vary widely according to the setting. Antenatal care coverage also varies according to age, parity, education, area of residence, socio-economic status of women (WHO 2003).

There is little consensus on some critical aspects of antenatal care such as the number of visits and the most cost-effective components of antenatal care. A systematic review of randomised controlled trials was conducted to examine whether a model of antenatal care with a lower number of visits would be as effective as the standard antenatal care model with or without goal oriented components as regards to maternal and perinatal/neonatal outcomes, maternal satisfaction, and costs (Carroli et al. 2001). This review found similar odds for multiple obstetric and birth outcomes between the two models, and concluded that antenatal care with a lower number of visits without goal oriented components could be introduced into primary care setting at lower costs without significant risk to the mother or newborn. There have been very few community-based studies on the impact of antenatal care on perinatal/neonatal outcomes.

A recent analysis (Hong and Ruiz-Beltran 2007) of nationwide data from the Bangladesh Demographic and Health Survey 2004 found that mothers who did not receive antenatal care were more than twice as likely to lose their infants during infancy compared to mothers who received antenatal care (Hazard ratio 2.40; 95% CI: 1.74-3.31). Being an observational study, no causal association could be inferred from the study. However, the finding nevertheless reaffirms that antenatal care services at the community level could play a key role in improving child survival.

Another important but often overlooked function of antenatal care is that it helps to socialise and connect women with the health services (Bhutta et al. 2004; McDonagh 1996; Vanneste et al. 2000; WHO 1994).

In summary, although the evidence of antenatal care on saving the lives of mothers and infants is somewhat mixed, the overall consensus is that quality antenatal care can reduce the risk of maternal mortality and adverse pregnancy outcomes within a functional health care system.

2.15.6 Reproductive services during delivery

Many factors relating to labour/delivery can contribute to perinatal mortality. Some factors are related to the health care delivery system, such as the obstetric skill of health care staff, medical supplies, community preparedness and transport systems. Other factors are specific to the woman herself, such as delayed presentation at health facilities, twin pregnancy, dystocia, and eclampsia. Maternal complications at delivery are important risk factors for perinatal mortality, and nearly 7 million perinatal deaths every year can be attributed to maternal complications (Kusiako, Ronsmans, and Van der Paal 2000; Lawn, Cousens, and Zupan 2005). Thus, improving care for the mother with skilled attendance at delivery can contribute towards a reduction of both perinatal and maternal morbidity and mortality (Bell et al. 2003; Kusiako, Ronsmans, and Van der Paal 2000).

Skilled attendance is considered a process through which the pregnant woman is provided adequate care during labour, birth and the post partum period. This process has two important components - a skilled attendant and an enabling environment. According to WHO, a skilled attendant is defined as a person (doctor, midwife or nurse) who has the necessary midwifery skills to adequately manage normal deliveries and diagnose or refer obstetric complications. The definition of an enabling environment is less clear, but adequate and appropriate equipment, supplies, drugs, and organization of facilities including transportation for referrals are the main constituents (Bell et al. 2003; WHO 2000).

Coverage of services, quality of care and underlying cultural beliefs are pivotal considerations in the success of a programme. Utilization of clinical care involves both supply and demand factors. Common supply considerations include access, human resources, other supplies and quality of care, while demand factors include affordability, acceptability, and compliance (Knippenberg et al. 2005).

A recent review examined the relationship between levels of neonatal mortality and skilled attendance, and found that countries where neonatal mortality declined successfully had a high proportion of births conducted by skilled attendants that were supported by community-based services (Knippenberg et al. 2005). The review revealed that where skilled attendance rates were less than 30% of total births, with the majority of births being home deliveries, the NMR was usually more than 45 per thousand live births. Skilled attendance rates between 30-65% with a mixture of home and facility-based deliveries, were generally associated with NMRs of 30-45 per thousand live births. Where skilled attendance rates are 61-95% of all births, with the majority being in health facilities, the NMR was 15-29 per thousand live births. An NMR of less than 5 per thousand live births is usually associated with a skilled attendance rate of more than 95%, with almost all deliveries in health facilities.

Skilled attendance during home delivery is uncommon in developing countries such as Bangladesh. Kusiako and colleagues (Kusiako, Ronsmans, and Van der Paal 2000) did an analysis of maternity data on 17,000 pregnant women, 62% of them had received either antenatal care or delivery care or both from midwives at Matlab. The analysis was aimed to identify perinatal risk factors attributable to delivery complications. The maternity project was carried out between 1987 and 1993 and used professional midwives for providing both antenatal care at home, and delivery services at the sub-centre or at home when called for home delivery services. The researchers did not find any significant difference in perinatal mortality rates between those who had contact with midwives either during antenatal care or delivery or both and those who had no such contact (perinatal mortality 60.2 and 58.3 per 1000 live births respectively; OR 1.03; 95% CI: 0.91-1.18). However, the study found significantly higher perinatal mortality rate in women who had both antenatal and delivery care compared with those receiving either antenatal care or delivery care (perinatal mortality 71.4 and 48.2 per 1000 live births respectively; OR 1.51; 95% CI: 1.28-1.79). The authors suggested improving the training of midwives in labour management and care of neonates supported by referral mechanisms to improve perinatal health. The study findings may be biased towards complicated deliveries and labour as the study only analyzed women who had received antenatal care or delivery care or both from midwives. Women may be more likely to call the midwife or to attend a health centre when a problem occurs.

Another study recruited 1020 pregnant women from the four administrative divisions of Bangladesh using a multistage random sampling method (Bari et al. 2002). Prospective data from six months of pregnancy up to 90 days postpartum found that assisted delivery was associated with a higher risk of stillbirths and death during the first week of life. The study reported a 27% excess perinatal mortality with deliveries in hospital or clinic compared to home deliveries (OR 1.28; 95% CI: O.29-5.61). Possible reasons postulated for such an increased risk for assisted deliveries were that high-risk women or those with obstetric complications attended the hospital/clinic without prior antenatal care, and/or that the hospitals/clinics failed or were not prepared to provide adequate delivery and neonatal resuscitation care.

A more recent case control study was carried out to identify risk factors for neonatal mortality in Bangladesh (Mercer, Haseen et al. 2006). Women whose newborn had died within one month of delivery were the cases while those with newborns surviving beyond 28 days were the controls. The study found that the relative risk of dying was lower, but not significantly, (crude odds ratio 0.7; 95% CI: 0.1-3.5) when deliveries were assisted by a qualified birth attendant. However, the small number of deliveries assisted by qualified attendants limited the generalizability of the study findings.

The effectiveness of using trained birth attendants has been studied by Sibley and Sipe (2004) who conducted a meta-analysis of data from 60 studies from 24 countries in three regions of the world. They found that training traditional birth attendants (TBA) were associated with a 8% (95% CI: 4-9%) reduction of peri-neonatal mortality and a reduction of 11% (95% CI: 2-21%) in asphyxia-related death (Sibley and Ann Sipe 2004).

2.16 Intervention Through Neonates

2.16.1 Newborn resuscitation

The World Health Organization (WHO) defines birth asphyxia as a condition when a newborn fails to initiate and sustain breathing at birth. Birth asphyxia is estimated to account for one-third of the four million neonatal deaths that occurs annually and is ranked as the third major cause of neonatal death after infections and preterm births (Lawn, Cousens, and Zupan 2005; WHO 1997). WHO estimates that 3% of the approximately 120 million infants born every year in developing countries develop birth asphyxia and require resuscitation. Of these, around 900,000 die each year (WHO 1997). Based on a literature review, it is estimated that 24-61% of perinatal death can be attributed to birth asphyxia (Ellis and Manandhar 1999).

It is estimated that 50% of cases of birth asphyxia are due to factors related to the ante partum period, 40% due to factors in the intra partum period and the remaining 10% due to factors related to post partum period (Dilenge, Majnemer, and Shevell

2001). Therefore, interventions are required for every period of the pregnancy to reduce birth asphyxia-related neonatal death.

It is difficult to predict birth asphyxia before delivery, except in cases of foetal distress and preterm birth, hence all newborns should be considered at risk of birth asphyxia. Ideally, all birth attendants should be competent in newborn resuscitation and be appropriately equipped and resourced during the delivery period.

Studies have identified some effective as well as some ineffective/harmful resuscitation practices. When newborn resuscitation is mentioned, many health professionals, programme managers, and policy makers think that it requires modern resuscitation equipment, oxygen cylinders and neonatal intensive care. However, as will be described below, neonatal resuscitation can also be effectively practiced in low-resource settings.

Effective and required three basic skills at health centre

According to WHO, basic resuscitation can prevent more than three quarters of newborn deaths due to birth asphyxia (WHO 1997). Basic resuscitation principles include the importance of maintaining or ensuring a normal body temperature by drying and wrapping, and the necessity of cleaning the airway by correctly positioning the baby's head. In specialised health centres, suctioning or inserting endotracheal tubes is used to maintain a clear airway, and it is important to inflate the lungs with air if this is required. Studies have shown that bag or tube and mask technique is adequate to provide ventilation to an asphyxiated newborn. It is also shown that room air is as good as oxygen for resuscitation (WHO 1997; Ramji et al. 2003).

Ineffective/harmful resuscitation practices

There are resuscitation practices that are performed routinely by birth attendants in health facilities without any evidence of benefit to the baby. Some may even be harmful. The practices that should be avoided (WHO 1997) include:

1) the routine aspiration of upper airway using a suction machine if the newborn starts crying or breathing immediately after birth. Routine suction is often associated with hazards such as cardiac arrhythmia.

2) the routine gastric suctioning as it provides no benefit, and can often be hazardous.

3) encouraging postural drainage by holding the newborn upside down by the legs and slapping the back is not effective and could be dangerous.

4) squeezing the chest to remove secretions from the airway as it is also dangerous and may cause fracture, lung injury and death.

5) use of sodium bicarbonate in the immediate postnatal period if there is no documented metabolic acidosis. Even in documented acidosis cases, it should only be used after establishment of respiration and in an appropriate concentration.

There are programme options both at health facilities and at community level to improve the management of asphyxiated babies with and without equipment. A few of these are discussed below.

Considering birth asphyxia is a huge problem in India and globally, Bang and his colleagues evaluated the management of birth asphyxia as a part of a package of home-based interventions (Bang, Bang, Baitule et al. 2005). Their study was conducted in the Gadchiroli district of India during 1996- 2003. The study evaluated the impact of home-based neonatal care on birth asphyxia and compared the effectiveness of two types of workers (traditional birth attendant and village health worker who were semi-skilled trained staff) and three methods of resuscitation in home deliveries. Interventions included the traditional birth attendants (TBA) using mouth to mouth resuscitation in the baseline periods (1993-1995). A semi-skilled category of village health worker (VHW) was trained and observed delivery and neonates in the observation period (1995 to 1996). This VHW along with TBA used the tube-mask (1996 to 1999) and bag-mask resuscitation technique when a baby was identified to have birth asphyxia. They used a stepwise procedure for identifying birth asphyxia, applying resuscitation devices, and recording all procedures and outcomes in a record book.

The study showed a 60% reduction in the incidence of birth asphyxia from 14% in the pre-intervention observation period (1995 to 1996) to 6% in the intervention years ($p<0.0001$). The case fatality of birth asphyxia was reduced by 47.5% from 39% to 20% ($p<0.07$), and the asphyxia specific mortality rate was reduced by 65% from 11% to 4% ($p<0.02$). The study concluded that home-based interventions delivered by a team of TBA and a semi-skilled VHW reduced the asphyxia-related neonatal mortality by 65% compared to a TBA only. The bag-mask appeared to be superior to the tube mask or mouth-to-mouth resuscitation. The estimated cost of averting an asphyxia-related death was US$13 (Bang, Bang, Baitule et al. 2005). Similar success had also been reported from a community-based study conducted in Cirebon district, Indonesia (PATH 2006). The study trained village midwives about the basic principles of resuscitation and how to manage birth asphyxia in 2003. The study reported a significant reduction of birth asphyxia specific neonatal mortality rate by 47% as well as neonatal mortality rate by 40% within one year of introducing the programme.

2.16.2 Interventions against infection

Neonatal infection is one of the major causes of morbidity and mortality (Bhutta 1999). The lack of vernix, a protective cutaneous covering, in the skin of the preterm newborn makes the infant susceptible to infection. Conducting and managing delivery practice hygienically and strengthening the skin barrier by the application of appropriate emollients reduce the incidence of neonatal infection (Darmstadt, Nawshad Uddin Ahmed et al. 2005; Darmstadt, Saha et al. 2005). Ensuring early exclusive breastfeeding, preventing and treating hypothermia, managing birth asphyxia and high risk babies for sepsis, all have an impact in preventing neonatal death from sepsis (Bhutta et al. 2005; Darmstadt, Black, and Santosham 2000; Moss et al. 2002).

Around two-thirds of infant deaths in countries such as India occur in the first four weeks of birth and the large majority of neonates die due to septicaemia, respiratory infections and meningitis (Paul 1999). Thus, considerable reductions in infant mortality can be achieved by developing and successfully implementing interventions during neonatal period. While the most effective way for managing ill neonates is to hospitalise them, hospital care is often either inaccessible or expensive to people in rural areas.

Bang and his colleagues (Bang et al. 1999) showed that it is possible to halve the infant mortality rate in populations with poor economic and nutritional status and with low female literacy by providing inexpensive health education and home-based neonatal care. Their study was conducted in Gadchiroli district in Maharasthra, India, and evaluated a package of home-based neonatal care in 39 villages during a three year period (1995-1998).

In the first year, information was collected for planning in order to develop an appropriate intervention. The first year activities were: listing pregnant women by female village health workers, collecting baseline information in the third trimester, observing the birth and the neonate at birth, and measuring neonatal weight and recording morbidity by making frequent home visits until four weeks after birth.

In the second year of the study, female health workers were trained and started implementing home-based management of neonatal illnesses. Programme activities included training female health worker, identification of neonates with possible infections and administering antibiotic treatment (an injection of Gentamicin and oral Co-trimoxazole syrup), and providing health education to the mother and grandmother about care. The nearby 47 villages were used as control comparison area for assessing the impact of intervention. Results showed a net reduction of 62%, in neonatal mortality rate in the intervention area as compared to the control area. In absolute terms, the neonatal mortality rate in the treatment area fell from 62 deaths per 1000 live births in the baseline period (1993-1995) to 25.5 in 1997-98, while it slightly increased from 57.7 to 59.6 in the control villages over the same period. Case fatality in neonatal sepsis declined significantly between pre-treatment (16%) and after treatment (3%) by the village health workers. The cost of home-based neonatal care worked out to about US$5.30 per neonate, of which $3.80 was the recurrent cost (Bang et al. 1999).

2.16.3 Low birth weight and hypothermia management

Low birth weight (LBW) occurs in two thirds of early neonatal deaths, and this is common in Southeast Asia including Bangladesh where the proportion of LBW births varies between 30% and 50% (Arifeen, Black, Caulfield et al. 2001; Goodburn, Chowdhury, and Gazi 1994; Wardlaw 2004; Paul 1999).

Newborns with LBW/prematurity are extremely susceptible to developing hypothermia, which is associated with a higher risk of morbidity and mortality (Christensson et al. 1998). The hypothermic infant can develop complications such as hypoglycaemia, metabolic acidosis, hypoxia, respiratory distress, and gastrointestinal problem (McCall et al. 2005). It is difficult to keep newborns sufficiently warm despite following the thermal guidelines (WHO 1997), as their body temperature may drop critically unless immediate action is adopted following birth. However, a few simple measures can reduce the development of hypothermia. These measures include keeping the delivery room warmer, drying and warming of newborns immediately after birth, delay in bathing of newborns, starting breastfeeding shortly after birth, and adopting the Kangaroo Mother Care (KMC) technique (Moss et al. 2002; WHO 1997).

KMC is a technique of care for low birth weight and preterm newborns, and it is now widely practiced as an alternative of incubator care in hospital settings in developed and developing countries (Conde-Agudelo, Diaz-Rossello, and Belizan 2003; WHO 1997) In KMC, the newborn is undressed, placed between mother's breasts in an upright position, and tucked inside the mother clothing, like a kangaroo in a pouch. The baby is dressed only with a diaper, a warm cap and a pair of socks. Studies to date shows that the KMC technique helps in keeping the baby warmer, improving breastfeeding, gaining weight, preventing infection, experiencing less apnoea, while increasing the mother's confidence for handling the baby and improving bonding (Bhutta et al. 2005; Christensson et al. 1998; Conde-Agudelo, Diaz-Rossello, and Belizan 2003; WHO 1997).

In Bangladesh, KMC has not yet been implemented routinely in the health facility setting, even though the country's rate of LBW is one of the highest in the world.

Recently, a pilot study evaluated the feasibility of implementing KMC at the community level in Bangladesh (Quasem et al. 2003). Mothers quickly adopted the intervention at the community level, with 77% of mothers initiating the skin-to-skin care.

2.16.4 Breastfeeding

Breastfeeding promotion is a key child survival strategy because of its protective impact on child morbidity and mortality, especially on post neonatal mortality. Although evidence is sparse for neonatal mortality, studies show that timing and type of breastfeeding play an important role in reducing mortality.

A study in rural Ghana during 2003-2004 underscored the great impact that early initiation of exclusive breastfeeding had on neonatal survival. The study found that 16% of neonatal deaths could be averted if all neonates were breastfed from their first day and 22% of deaths averted if breastfeeding started within the first hour (Edmond et al. 2006). The study revealed that the risk of mortality was four times higher in neonates given milk-based liquid in addition to breast milk compared to breast milk alone. The study also documented that late initiation of breastfeeding (after the first day) was associated with a 2.4 times higher risk of neonatal mortality.

Bahl and colleagues in a multi-country study (India, Ghana and Peru) evaluated the relationship between infant feeding patterns and the risk of death. A non-breastfed infant had an increased risk of dying within six month of birth when compared to a predominantly breastfed infant baby (HR 10.5; 95% CI: 5.0-22.0) as did partially breastfed infants (HR 2.46; 95% CI: 1.44-4.18). However, the study did not find any significant difference in the risk of dying between exclusive and predominantly breastfed infants (Bahl et al. 2005).

Information on the timing and cause of death plays an important role in selecting cost effective interventions. It is observed that late neonatal deaths (from 8-28 days) are more likely to be prevented by breastfeeding than are earlier deaths (<8 days), which are mainly related to newborn status at birth and delivery. Breastfeeding specially protects against late neonatal death from infectious death and malnutrition. In 2000, a WHO collaborative steady team on breastfeeding carried out a pooled analysis on breastfeeding data from six countries (Brazil, The Gambia, Ghana, Pakistan, the Philippines and Senegal). For the assessment of protection against infant mortality, studies from African countries were excluded because almost all babies were breastfed during infancy. The researchers, based on studies from non-African countries, reported that breastfeeding protects against infant mortality from infectious diseases. The protection was the highest for infants aged less than two months (OR 5.8; 95% CI: 3.4-9.8) and dropped with infant age. In the first six months, protection against diarrhoea (OR 6.1; 95% CI: 4.1-9.0) was substantially higher than against death due to respiratory infection (OR 2.4; 95% CI: 1.6-3.5), while the protection was similar for infants aged 6-11 months. The study also noted that protection was highest when maternal education was low (WHO Collaborative Study Team 2000). Another literature review examined the relationship between breastfeeding in the first months of life and neonatal mortality. The researchers found that feeding colostrum and breastfeeding, especially exclusive breastfeeding, protected against neonatal deaths from sepsis, acute respiratory infection, meningitis, omphalitis, and diarrhoea (Huffman, Zehner, and Victora 2001).

There is also evidence that breastfeeding is beneficial in helping to reduce early neonatal mortality. Huffman and colleagues' systematic review reported that breastfeeding prevented hypoglycaemia and hypothermia, which is often the contributory cause of death among low birth weight newborns. Suckling helps in preventing hypothermia by keeping the newborn close to the mother's body (Huffman, Zehner, and Victora 2001).

Furthermore, the early initiation of breastfeeding is vital because colostrum contains a high level of immunoglobulin, lactoferrin, and other factors, which protect the newborn from infection. An earlier randomised study in India evaluated the effect of breastfeeding and formula on the incidence of infection among low birth weight newborns in the first week of life (Narayanan et al. 1984). The study found that exclusively breastfed infants had the lowest infection rate (10.5%) when compared to the infection rate in newborns given pasteurised human milk and formula milk (33%), pasteurised human milk alone (14.3%), and raw human milk mixed with formula milk (16%).

Evidence shows that exclusive breastfeeding and early initiation of breastfeeding can be improved through different hospital and community-based counselling strategies. A randomised study from Bangladesh that evaluated the effect of peer counselling on establishing exclusive breastfeeding reported a high success rate of exclusive breastfeeding among women in the intervention area compared to the control area (70% vs. 5%) at 5 months (Haider et al. 2000).

2.17 Maternal and Child Health Care Programme

Most health settings use a package of maternal and child care interventions, but there have been relatively few studies to examine the impact of such interventions on perinatal and neonatal mortality. Such programmes are usually geared towards identifying high risk pregnant women, and their appropriate referral to higher level facilities. The MCH activities include antenatal care at community level, improved referral systems and facility-based care. One such programme in China included a three tier maternal and child health care services (village, township and county), and examined the impact of programme on perinatal and neonatal mortality over 1983-86 (Yan 1989). The programme coverage was very high, and achieved a reduction in the perinatal mortality rate by 34%, from 26.7/1000 to 17.6/1000 births. The neonatal mortality dropped from 14 /1000 to 8/1000 live births.

Even greater reductions in neonatal mortality with integrated reproductive health services have been observed in the community setting in Bangladesh. A 50% reduction in neonatal mortality between 1996 and 2002 was observed in 12 service areas of nongovernmental organizations carrying out outreach reproductive health activities, where the health facility delivery rate was around 11% (Mercer et al. 2004; Mercer, Uddin et al. 2006).

In a more controlled research setting in the Matlab area of Bangladesh, the reduction in neonatal mortality was of a lower but still significant magnitude (Hale et al. 2006). Of 126,000 singleton births during 1982-92, the early NMR (first week) declined by 15.8% from 31.8/1000 to 26.7/1000 live births in the MCH-FP project area with a relative risk ratio of 0.842 ($p<.001$), compared to the adjoining comparison government serviced area. Reductions in the subsequent post-early NMR (second through to fourth week) were even greater than the early NMR, with a relative risk of 0.631 for mortality (17.4/1000 in comparison and 11.0/1000 live births in MCH-FP area). Researchers concluded that 20% of the variation in mortality difference could be explained by reproductive patterns, while the remainder could be attributed to the effect of MCH-FP services.

CHAPTER 3
Methodology

3.1 Introduction

This chapter describes the research design and methodology used in the study. It first describes the study setting in terms of the geography, environment, health services delivery and research infrastructure. The chapter then details the study design, sample size, sampling, development of data collection instrument, staff training, piloting, data collection procedures, computerization and quality of data management and analytic plan.

3.2 Study Setting

3.2.1 Geography and study population

The study was carried out in Matlab, a rural sub-district in eastern Bangladesh, where an international research organization, the International Centre for Diarrhoeal Disease Research Bangladesh (ICDDR,B), has been running a community-based health and research programme since 1963. Matlab is a low lying, riverine area 60 kilometres southeast of Dhaka, the capital of Bangladesh (see Figure 3-1). There are 143 villages in Matlab each village being the smallest administrative unit with an average population of 1100. The population density in Matlab exceeds 950 per square kilometre. The climate is subtropical. Although there are six seasons in a year, climatologically there are three prominent periods- monsoon (July-September) with an average rainfall of 152cm, dry winter (October-February) with temperature range of 13-28°C, and a hot dry period (March-June) with temperature range of 26-38°C (Aziz 1994).

According to the ICDDR,B census of 2005, 88% of the people in Matlab are Muslims and the rest Hindus. Of the study population, 49% are males. The average life expectancy at birth is 64 years for males and 66 years for females. The principal occupations are farming, small business, salaried employment in private and public organizations, and fishing. Common crops include rice, potato, jute, and millets with rice the staple food. The participation of women in the workforce is limited for social and cultural reasons, and most women are housewives (HDSS-Matlab: 2005 socio-economic census 2007; Aziz 1994).

3.2.2 Research infrastructure

ICDDR,B's community level infrastructure in Matlab, a Longitudinal Health and Demographic Surveillance System (DHSS), is principally maintained by village-based female Community Health Research Workers (CHRW). The surveillance system has been in place since 1966. The surveillance area is divided into (1) an ICDDR,B intervention area (present population 110,000 in 67 villages) that receives a range of Maternal and Child Health and Family Planning (MCH-FP) interventions and services from ICDDR,B and (2) a comparison area (Government serviced area) with a population of 110,000 in 76 villages that receives standard Government services (HDSS 2002).

The CHRW carry out monthly household visits to collect information on demographic events (birth, death, migration, abortion, marriage, divorce etc) using pre-coded coloured forms to record the events. In addition, they collect and record data on illnesses and nutritional status in children under-five, the health status of reproductive age women, contraceptive use, and use of health care facilities. These data are collated and maintained in the HDSS databases (HDSS 2004). The types of data collected by CHRWs are identical in both the ICDDR,B area and Government serviced areas.

Programme staff assign a unique identification number to each household individual on their entry into the surveillance area through events such as birth, marriage and migration. A set of standard definitions are used for residents, households or *bari,* live births, stillbirths, in-migration and out-migration. The use of unique registration numbers makes it possible to link demographic, biomedical, and socio-economic data of each participant, and to draw random sampling frames for research studies.

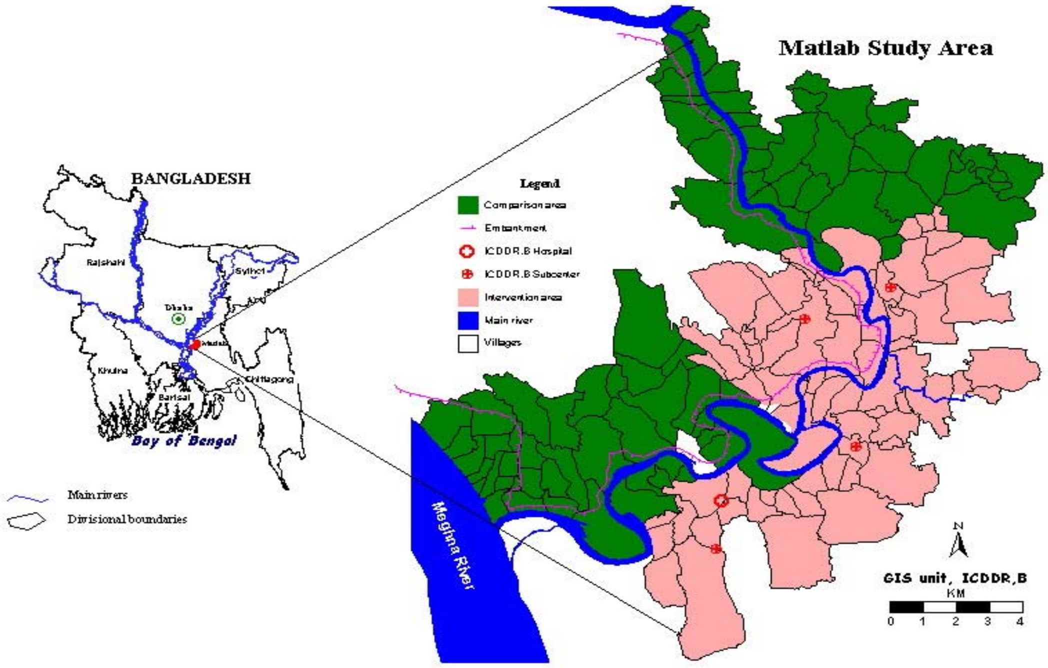


Figure 3-7: Map of Bangladesh and enlarged map of Matlab

3.2.3 Health services in study population

As described earlier, the Matlab surveillance area receives health services from two sources - ICDDR,B and the Government.

Health service delivery in the ICDDR,B-serviced area

The ICDDR,B service delivery structure includes 61 village-based Community Health Research Workers (CHRW) and four community health clinics, also known as sub-centre clinics, each of the latter serving around 28,000 people. Each sub-centre clinic is staffed by two nurse-midwives and one male medical assistant. ICDDR,B also maintains a primary-care hospital at Matlab sub-district town with out-patient, in-patient and basic laboratory facilities.

The Matlab ICDDR,B hospital mainly treats children aged under-five years who present with diarrhoea, acute respiratory infection, malnutrition, and/or other common problems. It also manages the health problems of women of reproductive age. Maternity care includes birth deliveries offered through the four sub-centre clinics and the Matlab hospital. Emergency obstetric care, including caesarean section, is organized as required through collaboration and referral with the government sub-district or upazila health complex at Matlab and with secondary level hospitals at Chandpur, the district headquarters. All health problems (women of reproductive age and children under-five years) are initially screened by CHRW either at the CHRW's home or during their monthly visit for consultation. The CHRWs assess these problems and manage minor illnesses such as low grade fever and mild pneumonia, referring the more severe cases to the sub-centre clinic for proper management. The paramedical staff based at the sub-centre provide necessary management and refer complicated cases to the Matlab ICDDR,B hospital for further care. Most of these patients are managed at Matlab hospital, with more complicated patients being referred to the government hospital for further specialized care, especially for surgical interventions.

ICDDR,B's community-based service activities include comprehensive family planning services, distribution of oral rehydration salts to treat diarrhoea, immunization against six common diseases, maternal immunization against tetanus during pregnancy, nutrition information, distribution of vitamin A for children under-five, and distribution of delivery kits, which include a sterilized blade, a small container of antiseptic liquid, a plastic sheet and a thread for tying the umbilical cord (Fauveau and Chakraborty 1994). During household visits, the CHRWs advise all pregnant women to seek antenatal care for any problem, and also encourage them to give birth at a health facility such as the ICDDR,B sub-centres or ICDDR,B Matlab hospital, regardless of whether they have any complications or not.

As evident from above, ICDDR,B attempts to maintain continuity of care through a standard referral system from the household level to the health facility level. ICDDR,B services are provided free of cost to women and children under-five.

<u>Service delivery in the Government-serviced area</u>

People from this area receive medical services from Government health facilities. The government maintains an extensive, albeit basic, health infrastructure throughout the country. At the lowest level, the Government facilities comprise the union health centre and the family welfare centre which are analogous to the ICDDR,B sub-centre in the services provided. These are managed by paramedics and medical assistants. There are 10 such centres in the comparison area within the surveillance area. The sub-district or upazila health complex is the primary referral centre, analogous to the ICDDR,B Matlab Hospital, with the exception that it also provides primary surgical care and essential obstetric care including caesarean sections and blood transfusion. The upazila health complex is run by physicians, nurses, a medical assistant and other staffs, and maintains good working links with the Matlab ICDDR,B Hospital, especially in terms of receiving the latter's complicated obstetric cases and cases requiring surgery.

Although medical facilities and services are similar in both areas, Government health services, as throughout Bangladesh, are plagued by scarcity of basic medical supplies and poor staff morale (Rahman 2006).

3.3 Design of the Study

This was an observational study and has two main components: (1) the first component aimed to determine the cause of death and its differentials, related reproductive and birth characteristics and the patterns of treatment received during the fatal illness episodes, and the evaluation of the diagnostic accuracy and reliability of MA review and computer-based expert algorithm for assigning cause of neonatal death. (2) The second component aimed to identify predictors of neonatal mortality.

For the first component, the mother or close family member of the deceased child was interviewed at home using a VA questionnaire. A computer-based clinical algorithm was developed based on published algorithms for classifying and evaluating the cause of death.

For the second component, all live births during 2003 and 2004 were listed from birth registration data. This birth information was linked to the Matlab HDSS master database containing socio-demographic information (age, education, religion, occupation, parity), reproductive characteristics of mothers (antenatal care, place of delivery, service area) and birth characteristics of newborns (sex of newborn, birth month, year of death and plurality of birth) to identify the predictors of neonatal death.

3.3.1 Sample size

a) For description of the characteristics of death, health care consultation, cause of death, and comparison of methods for assigning cause of death, neonatal deaths that occurred in 2003 and 2004 in both the intervention and comparison areas of the HDSS were included in the study. These deaths numbered 365.

b) For identifying predictors of neonatal death, all live births and neonatal deaths during 2003 and 2004 were included for analysis. These totalled 11,291 live births including the 365 neonatal deaths.

3.4 Data Collection Instruments

A VA questionnaire was administered at the household level to collect information on fatal illness episodes and associated events prior to death. In 2002, a neonatal VA questionnaire (see Appendix A & B) for the Matlab HDSS was developed based on work carried out by the researcher at the IN-DEPTH VA Working Group meeting held in Tanzania mentioned earlier. The generic questionnaire was modified and translated into Bangla for implementation in the Matlab HDSS. Modifications included, for example, the deletion of questions on HIV/AIDS or malaria, as these were not relevant for the area (ICDDRB 2003; HDSS 2004; Hawkes et al. 2002). The questionnaire included instructions for the interviewer about how to introduce themselves to the respondents and establish good rapport with them. There were also guidelines on how to select the main respondent for the interview. The questionnaire had the following sections:

A. Events concerning mothers: these were elicited through structured questions on the history of complications during pregnancy and delivery, and the mode and place of delivery for neonatal death cases.

B. Events concerning deceased neonate: these were also elicited through several structured questions about birth characteristics (date of birth and death, sex of babies, plurality of birth, size at birth, birth weight) and the clinical manifestations (signs and symptoms) during the fatal illness episode.

C. Medical consultation: there were also structured closed-ended questions on health seeking patterns especially health services utilization (categories of providers order of consultation and number of consultation) and place of death.

Open history section: This section included instructions on how to record unprompted responses about the details of illnesses including care seeking prior to death, in response to an open-ended question. Whenever possible, the local terms used to describe key events in the history were recorded.

Interviewer comment and observation: especially important for suspicious death such as homicidal or suicidal death

Main respondents were considered for selection in the VA if they were:
(a) Closely related to the deceased newborn, and usually the mother
(b) Present during the illness that led to death
(c) Able to provide details of the fatal illness episode and the medical consultations prior to death.

There was also provision for supplementing the information from other people to complete the history.

Informed consent was always obtained prior to the interviews.

The cause of death was assigned and recorded on a separate sheet by each medic.

3.4.1 Birth registration forms

HDSS has been using birth registration forms for recording birth events since 1966. In 2003, the form was modified to include additional information on reproductive characteristics of women. The form contains the sex of the newborn, single/multiple birth, outcome of pregnancy (stillbirth, live birth), history and site of antenatal care, place of delivery, birth attended by, and whether the newborn cried after birth.

3.4.2 Socio-demographic information

HDSS updates its master database with monthly or periodic census data, and this was used to extract information on socio-demographic variables corresponding to the appropriate unique identification number.

3.5 Staffing, Training, and Piloting of VA Questionnaire

3.5.1 Community Health Research Worker (CHRW)

Community Health Research Workers, who are multi-purpose village-based female workers, are recruited from the community through local advertisements. They have to sit for a written and oral examination for selection. Other criteria for CHRW selection are: they must be resident in the DSS area with a DSS assigned identification number, and have a minimum of 10 years of education and be willing to work in the community, walking from house to house. On recruitment, they are provided with a four week theoretical and practical training about the different activities in the Matlab programme. The training includes collection, coding and recording of data on the different data collection forms including the birth registration form. Training and retraining is an on-going process as per changes in the data collection instruments or other areas of work.

3.5.2 Recruitment of interviewers for verbal autopsy

In 2003, a VA team was formed with five field assistants, a Medical Assistant (MA) with three years of formal medical schooling, a medical demographer, and a public health physician (the doctoral candidate) to undertake the VA study. The field research assistants were non-medical staff with at least 10 years of schooling and already had field data collection experience. The researcher (candidate) had the responsibility of designing the questionnaire, translating questionnaires, training the interviewers, briefing physicians and medical assistant involved in assigning causes of death, and supervising technical aspects of VA data collection.

A week long training session was arranged for the VA team, which was facilitated by the candidate and the demographer. The team was oriented about the content of the VA questionnaire, techniques of interviewing, and the processes around informed consent. After the training, team members practiced the interview questions among themselves. Each member then piloted the questionnaire on two neonatal deaths from the list of neonatal deaths in 2002. Completed questionnaires were discussed, including wording and flow of questions before the final Bangla version of the VA questionnaire was developed. The same team was responsible for conducting VA interviews for all the neonatal deaths in 2003 and 2004.

3.6 Data Collection Procedure

CHRWs identified the deaths and filled up a registration slip (date of death, identification number etc) during their house-to-house visit and sent it to the block supervisor. These were then uploaded to the HDSS records. A VA trained interviewer made a field visit 2-6 weeks after the date of death to conduct the VA interview. After obtaining informed verbal consent, the interviewer conducted the interviews in the local language. Descriptive statements were recorded in the open part of the questionnaire, preserving local idioms and refraining from any alterations or translation. Interviews generally lasted for 40 to 60 minutes depending on the illness history and the emotional state of the caretakers.

CHRWs collected information on the birth registration form during their monthly home visits. New events such as a birth, death, migration, marriage or divorce were recorded on the family visit card kept at the household. When a birth occurred, CHRWs interviewed the mother using a structured questionnaire on whether antenatal care (ANC) services had been availed during the first, second and last trimesters, and if so, what type of services, the type of birth attendant involved, the place of delivery, and some questions about the newborn such as sex of the newborn and whether it was a singleton or multiple birth (HDSS 2004).

3.7 Procedure for Assigning Cause of Death

3.7.1 Physician and medical assistant (MA) review

The doctoral candidate briefed the three participating physicians (two female and one male who worked at the Matlab hospital) about the project activities. The briefing included the definitions of direct and originating/underlying causes of death, and the WHO/IMCI guidelines for the integrated management of childhood illnesses. Their role was to review all sections of the questionnaire including health care seeking and to assign direct and originating causes of death using the ICD-10 codes (WHO 1993).

A Medical Assistant (MA), who had three years of formal medical schooling, was provided briefing/training similar to the physicians above to independently review the same information to assign causes of death.

3.7.2 Expert (clinical) algorithms

Neonates in the first week of life typically suffer serious illnesses from conditions such as prematurity, low birth weight and respiratory distress syndrome, while older neonates are more susceptible to infections such as sepsis and pneumonia. Hence, treatment guidelines for primary health care workers will need to factor in these age-dependant variations in clinical presentations. However, the limited repertoire and non-specific nature of signs and symptoms limit a clear classification of neonatal illness episodes. Considering this, the World Heath Organization (WHO) has identified a list of signs and symptoms that can be used to classify neonatal diseases (Government of the People's Republic of Bangladesh, WHO, and UNICEF 2001). Considering the differences in management at various age points and the relative certainty of some diagnoses, computer-based hierarchical algorithms have been found to be helpful to assign causes of neonatal deaths.

The hierarchical process consists of several tiers of mutually exclusive causes, as shown in the figure below. The flow order of the tiers is based on the relative certainty of each cause, with the most common neonatal causes being represented in the flow chart. For this study, a computer-assisted algorithm of the above hierarchical process was developed using the Stata software version 9. Standardised definitions from the published literature were used for causes of death (Baqui et al. 2006; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005; WHO 1999, 2000) as detailed below.

Neonatal tetanus

Death from neonatal tetanus was defined as death of a neonate between 3-28 days, where the neonate had cried normally after birth, and had convulsions during this period and had stopped suckling breast or crying during the fatal illness episode.

Congenital abnormality

Congenital abnormality was assumed to be the cause of death when the mother/respondent reported that neonate had a malformation at birth.

Prematurity/Low birth weight

Prematurity/low birth weight was assumed as a cause of death when the mother/respondent reported that the neonate was very small at birth regardless of the birth weight and gestational age.

Birth asphyxia

Birth asphyxia was assigned as a cause of death when age at death was less or equal to 7 days, with the newborn not able to cry normally after birth and not able to breathe normally after birth

Birth injury

Birth injury was considered as a cause of death when the mother/respondent reported that the neonate had bruises or marks of injury on the body or head at birth.

Diarrhoea

Diarrhoea was assigned as a cause of death when the mother/respondent reported that the neonate had frequent liquid/watery stools during the fatal episode

Respiratory distress syndrome (RDS)

Respiratory distress syndrome was considered as a cause of death if the mother/respondent reported that the neonate had difficulty in breathing or had fast breathing during the fatal illness episode and it had started in the first 24 hours of birth.

Pneumonia

Pneumonia was assigned as a cause of death if the mother/respondent reported that the neonate had difficulty in breathing or had fast breathing that started after 24 hours of birth. The neonate would also have grunting and chest in-drawing during the fatal episode.

Meningitis/Sepsis

Meningitis/Sepsis was assigned as a cause of death if the mother/respondent reported that the neonate had at least two of the following signs of serious infection:

1. Convulsion
2. Unconsciousness or lethargy
3. Bulging fontanelle
4. Rapid/fast breathing
5. Chest indrawing
6. Fever or skin cold to touch
7. Stopped suckling
8. Redness or drainage from the umbilical cord stump
9. Skin bumps containing pus or blister
10. Vomiting

No cause identified

Neonatal death was labelled as “no cause identified” if no cause could be assigned for neonatal death in tiers 1 to 9 of the hierarchical algorithm.

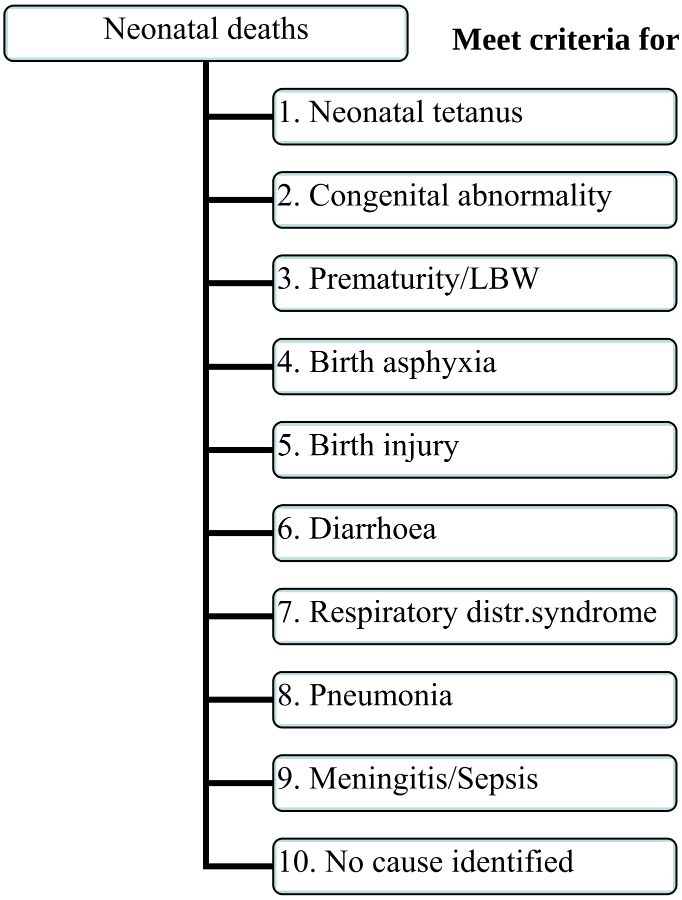


Figure 3-8 Flow chart showing hierarchical order of algorithm used for classifying cause of deaths

The study algorithm was adapted from the version used in India (Baqui et al. 2006). However, it was different in some aspects from the one used in the classification of childhood deaths during the Bangladesh Health and Demographic Surveillance (BDHS) data analysis (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005), as the algorithm used here was exclusively developed for classifying neonatal deaths. There are changes in the order of causes as well as in the definition of some of the categories of death from those used in child deaths. For instance, low birth weight/prematurity was defined by the mother reporting only very small size at birth regardless of birth weight and gestational age. In the absence of birth weight and gestational age, which was not available in most cases, size at birth was estimated by interviewing the mother. In a setting where low birth weight is very common, it has been documented that small size at birth is highly likely to be considered by parents as normal (Freeman et al. 2005). Terms like “smaller than normal” or “slightly smaller than normal” can be ambiguous and can misclassify the proportions of prematurity and low birth weight.

In the BDHS algorithms, respiratory distress syndrome (RDS) was not included as a category of cause of death. However, in the present study, RDS was categorised separately under its own name, and referred to the condition in neonates where there was difficult breathing or fast breathing during the fatal episode which started within 24 hours of birth. This definition was developed based on the suggested criteria for RDS in the guidelines for the Integrated Management of Childhood Illnesses (IMCI) and in a study in India (WHO 2000; Bang and Bang 1992; ICDDRB Web Page). RDS is often a complication of prematurity, and fast breathing starts within 24 hours. The management strategy is also different, so it was logical to distinguish the syndrome from pneumonia. In the hierarchy of the algorithm, RDS appeared before pneumonia.

Similarly, prematurity/low birth weight was placed in the 3rd tier instead of 7th in the BDHS 2004 algorithms. Neonates in this category are susceptible to immediate non-infective complications and late infective complications. It was thought that putting the complication of prematurity/low birth weight at this tier would pick up very small babies who are prone to non-infective complications of low birth weight/prematurity.

3.8 Data Entry and Management

3.8.1 Management for verbal autopsy data

A programmer from ICDDR,B helped develop a programme using the Visual Fox Pro software to enter and manage data from the VA questionnaire. A trained data entry person entered all VA information into a computer. Causes of neonatal death assigned by physicians and medical assistant were entered into the computer. Frequencies of individual variables and cross tabulation of recoding variables were generated for checking data quality. Area codes were included in the VA database by merging a file with village codes using sorted child identification number. Depending on location of village, codes were recoded and a new dichotomized variable termed “sarea” was created (ICDDR,B service area and Government service area). The VA variables were labelled, defined and assigned values. Necessary coding and recoding were carried out prior to analysis. Neonatal causes of death were grouped into the following categories for comparison:

- Neonatal tetanus
- Congenital abnormality
- Prematurity/low birth weight
- Birth asphyxia
- Birth injury
- Diarrhoea
- Respiratory distress syndrome
- Pneumonia
- Meningitis/sepsis
- Other specified causes
- Unspecified cause

Prematurity/low birth weight referred to small/light for date babies and low birth weight or premature babies. Sepsis and meningitis were also similarly grouped together for reporting and comparison.

During coding and recoding data, the cause of death (assigned by physicians, medical assistant or algorithm) was dichotomized into yes and no at the respective variables for that cause for assessing reliability and diagnostic accuracy of cause assigning method.

3.8.2 Management of HDSS database

Birth and other routinely collected information from HDSS population using different colour forms were edited, coded and entered into a computer at Matlab and sent to Dhaka for data processing. A computer programmer supervised the data entry. Information on demographic and reproductive characteristics of the mother and the birth characteristics of all live births and neonatal deaths during the years of 2003 and 2004 were accessed by linking the HDSS database using child and mother identification numbers. Labelling, defining and assigning value labels to each variable were then carried out. Coding and recoding were used to prepare the data for assessing relationship and multivariate analysis.

3.9 Data Quality Control

A field research officer, under the supervision of the manager of HDSS, made random spot checks to supervise the field data collection. During their visits, they checked data forms for consistency and accuracy. In addition, a quality control team consisting of two female field research assistants randomly surveyed a predetermined proportion of completed forms, and checked the authenticity of information by re-interviewing the mother/respondent. The quality control workers were under the administrative supervision of an ICDDR,B senior staff member who was not directly involved with HDSS activities.

Another important activity for ensuring quality information was the fortnightly meeting of HDSS workers that took place at the sub-centres in the surveillance area. The manager, supervisors and doctors from Matlab office attended the meetings to discuss and resolve problems encountered in the preceding two weeks in the field. These meetings provided a good opportunity to consolidate understanding and knowledge of question type and data collection methodology among the project staff. On-going training was provided at these meetings where data collection instruments and procedures were reviewed and the importance of standardised methods was stressed. The doctoral candidate, who was based in Matlab at the time of the study, remained available to clarify any queries regarding the VA questionnaire and data collection procedures.

Data errors were also minimised during data entry. A data entry screen in Oracle was organized so that on entering the respondent's unique identification, the basic information of the respondent appeared on the screen automatically, and only new information needed to be entered. Given the high frequency of household visits, this ensured a fairly reliable and complete detection and recording of events such as births and deaths in the HDSS area.

3.10 Verbal Autopsy Data Analysis and Statistical Methods

3.10.1 Simple frequency statistics of neonatal death cases

Age at death (day) was calculated by subtracting date of birth from the date of death. Neonatal deaths were categorized into several age categories. Simple descriptive statistics of variables (respondents, maternal complications, clinical manifestations during fatal episodes, age at death and neonatal death rate) in VA database were generated in the form of tables and graphs.

3.10.2 Comparison of maternal and newborn's characteristics by service area

Chi-square (χ^2) test or Fisher's exact test was applied to test the likelihood that test results occurred by chance, and a probability value ≤0.05 was considered as significant. Cross-tabulation was conducted with mode of delivery, place of delivery, plurality of births and birth weight as independent variables and service area as dependent variables. Size at birth was also compared by service areas and by birth weight categories.

3.10.3 Health care

Health care consultations during fatal illness episode were described using simple descriptive statistics. Health services providers were cross-tabulated with service areas, sex of newborn and age at death. The number of treatment visits was also compared by sex of newborn, age at death and service area.

3.10.4 Cause of deaths and its differentials

As three physicians were involved in the review process for assigning cause of death, only those causes of death where at least two physicians agreed were used for reporting direct causes of death. The process of identification of physician assigned causes was done in three steps. First, all 365 cases were reviewed for their direct causes of death. Of these, in 152 cases all three physicians agreed on the cause of death. In another 174 cases, two physicians agreed on the direct cause of death. This left 39 cases where there was no physician agreement. In these 39 cases, the direct and originating causes of death were reviewed to check whether there could be agreement between any of the physician-assigned direct cause with the originating cause of any of the other two physicians - 13 such cases were found. This still left 26 cases where there was no agreement between originating and direct causes.

3.10.5 Descriptive statistics on cause of death

Frequency tables were generated for causes where at least two physicians had agreed. This cause of death was compared by service areas, sex of newborn and time period of death using χ^2 tests.

3.10.6 Comparison of methods for assigning causes of death

<u>Inter method reliability and kappa statistics for assigning causes</u>

Cause-specific mortality fraction (CSMF) of major causes of death was calculated for each physician, the medical assistant, two physician-agreed and algorithm and is reported in the results section. The inter-method reliability (agreement) and kappa scores on the major causes of death were calculated between each physician and medical assistant (MA), and again between each physician and algorithm separately. This enabled determination of the proportion where each physician agreed on a cause with the medical assistant and algorithm. Agreement between the two methods or raters was calculated, as shown below.

		Method 1		
		Yes	No	
Method 2	Yes	a	b	a+b
	No	c	d	c+d
		a+c	b+d	a+b+c+d

Figure 3-9 Estimation of agreement between two methods

$$\text{Percent agreement} = \frac{a + d}{a + b + c + d} \times 100$$

$$\text{Chance agreement for each cell} = \frac{(\text{row total}) \times (\text{col total})}{\text{Grand total}}$$

$$\text{Kappa (k)} = \frac{(\text{\% agreement observed}) - (\text{\% agreement expected by chance alone})}{100\% - (\text{\% agreement expected by chance alone})}$$

The Kappa (k) statistic is a reliability test to compute the score, after adjusting for chance, showing agreement between methods/raters, and is used for categorical measures. Kappa statistics were calculated between the dichotomised outcomes of physicians and MA review, and also between physicians and algorithm. The following scale was used to rate the strength of agreement: a $k<0.21$ was considered poor, a k between 0.21 and 0.40 fair, a k between 0.41 and 0.60 moderate, a k between 0.61 and 0.80 good, and a $k >0.80$ very good (Altman 1991).

Diagnostic accuracy and reliability of methods for assigning causes

Diagnostic accuracy (at least 2 MOs agreeing on the cause as reference category) of medical assistant review and algorithm method was evaluated using sensitivity, specificity, and kappa statistics (Gordis 2004; Dawson and Trapp 2004).

Reference category		Yes	No	
Physician	Yes	a	b	a+b
	No	c	d	c+d
		a+c	b+d	a+b+c+d

Figure 3-10 Estimation of accuracy statistics between reference and evaluating method

$$\text{Sensitivity} = \frac{a}{a+b} \times 100 \qquad \text{Specificity} = \frac{d}{c+d} \times 100$$

$$\text{Positive predictive value} = \frac{a}{a+c} \times 100 \qquad \text{Negative predictive value} = \frac{d}{b+d} \times 100$$

For assessing the validity/accuracy of a method, namely its ability to distinguish between those with a specific condition/disease and those without, we used sensitivity, specificity and positive and negative predictive values. Test statistics were calculated based on the concept outlined above (Figure 3-10). There are no rule of thumb criteria to evaluate accuracy of VA technique for assigning causes of death. However, a study in Tanzania used criteria such as sensitivity >50% and specificity >1-CSMF as a gold standard, which did not result in any significant misclassification. Specificity is more important for validity assessment when CSMF is low (Setel, Whiting et al. 2006).

Sensitivity and specificity are defined as:

Sensitivity: the ability of a method (medical assistant review/algorithm assignment) to correctly classify those who have a specific condition/disease. It is expressed as a percentage.

Specificity: the ability of a method (MA review/algorithm assignment) to classify correctly those who do not have a specific disease.

Positive predictive values were calculated to assess what proportion of a specific cause of death classified by MA review or algorithms assignment were also classified as the same cause by physician review. Test statistics were expressed as percentage with 95% confidence intervals.

3.11 Live Birth and Linked HDSS Variables Data Analysis

The linked and merged datasets were used in the analysis of predictors of neonatal death.

3.11.1 Descriptive statistic of individual variables

Simple descriptive statistics were used to describe the relationships between neonatal mortality, the mother's demographic and reproductive characteristics and the birth characteristics of newborns to show the distribution of predictors and neonatal mortality in the sample.

3.11.2 Bivariate and multivariate binary logistic regression

Bivariate and multivariate logistic regressions were performed to assess the relationship and identify the predictors of neonatal death. Maternal demographic, reproductive and the newborn's birth characteristics were treated as independent variables while neonatal death was the dependent variable.

The 13 predictor variables included:

Mother's demographic characteristics—

1. Age at birth
2. Education
3. Religion
4. Occupation
5. Parity

Mother's reproductive characteristics—

6. First trimester antenatal care
7. Last trimester antenatal care
8. Place of delivery
9. Service area

Baby's birth characteristics—

10. Year of birth
11. Birth month
12. Sex of newborn
13. Plurality of birth (included only for the all live births analysis)

Analysis of singleton births

Univariate binary logistic regression (bivariate relationship) was carried out with neonatal death as the dependent variable and the 12 independent indicator variables separately to measure the unadjusted effect size (expressed as odds ratios) in predicting neonatal mortality. Results are reported with an unadjusted odds ratios with 95% confidence interval and with an overall p value for each independent variable.

Multivariate binary logistic regression: A standard (direct) binary logistic regression was performed as this method allows evaluation of the contribution made by each predictor while controlling for other predictors in the model. As the study purpose was to assess the predictive value of each covariate, all 12 predictor variables which had complete information were introduced simultaneously into the model. After running the logistic model, a test of significance was applied to calculate the overall differences (p values) between categories of each independent variable, and results are reported with adjusted odds ratios with 95% confidence intervals and an overall p value for each variable.

The backward stepwise elimination method was used to identify significant predictors. The regression model was run after removing non-significant variables one at a time from the full model until all those remaining in the model contributed significantly. A p value of <0.05 was considered significant. At each step, the variable with the largest p value was removed first, and so on as long as p was greater than 0.05. This model, with significant predictor variables was the constraints model or final model. This final model with only significant predictors reported the adjusted odds ratio, 95% confidence intervals and overall p values for each significant predictor.

To examine the interaction between place of delivery and antenatal care use during the last trimester, an interaction term "place of delivery and antenatal care use" was included in the model. The predictive ability of place of delivery and antenatal care use during the last trimester was assessed for neonatal mortality. Crude and adjusted odds ratios of place of delivery and antenatal care use with and without interaction are reported along with 95% confidence intervals in 2 × 2 tables.

Analysis of all live births (singleton and multiple births)

Bivariate, direct and backward stepwise random effects logistic regression were performed to calculate the point estimates of predictors of neonatal mortality using the mother as the unit of analysis

3.12 Model Statistics for Overall Results Fitting

To assess overall results from logistic model, Hosmer-Lemeshow's goodness-of-fit test was used after running the logistic model to determine whether the model could be accepted or rejected.

The test was based on the chi square distribution and generates model statistics. A p value of less than 0.05 indicates that the model's estimates fit the data at an acceptable level. The Receiver Operating Characteristics (ROC) curve area was also calculated both for models to see the acceptability of data fitting. Differences between two models were tested using Likelihood Ratios test (LR test).

3.13 Miscellaneous Data Management

A translation programme called Stat/Transfer 8 was used to convert data files into the Stata dataset for analysis.

Stata v9 was used to perform all analyses in the study. As part of the analysis, different user-written commands were used when necessary. For example, a programme for assessing diagnostic validity was identified and downloaded into the Stata software following hyperlink advice (StataCorp 2005).

For preparing tables in Word, Microsoft Excel was used as an intermediary. The tables were highlighted below the row heading of the result window in the Stata output, and the highlighted area copied. A Microsoft Excel window was then opened and the copied tables pasted in the Excel sheet, and necessary editing and formatting undertaken. Finally, the formatted tables of Excel were copied and pasted in the Word document.

3.14 Ethical Considerations

Prior to data organization (checking data form, assigning cause of death, computerization of VA data, and preparation of the linked dataset) and analysis, the research proposal was approved by the Human Research Ethics Committee of Curtin University of Technology and the Ethical Review Committee of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) (see Appendix C & D).

This section describes the general principles that were used to safeguard the rights of people participating in the study.

Prior to starting work, project staff were trained on their responsibilities towards respondents in relation to the latter's ethical rights.

Consent: whereby research participants have the right to know they are being researched and to know the nature of the research, and the right to withdraw from participation at any time. The purpose of the study was clearly explained to the participants. Participants were assured that neither participation nor refusal would have any effect on subsequent health care from ICDDR,B. No remuneration was offered for participation. Permission was sought to access records on treatment received before death. It is important to reiterate that ICDDR,B has been practizing obtaining oral consent before interview for collecting routine health and demographic data for many years

Confidentiality: the protection of the participants' identities and personal information is maintained and ensured as an imperative in all research activities of the organization. All named data collected were coded so that participants could not be identified.

Right to withdraw: this issue was emphasized to all prospective participants. The interviews could be discontinued or resumed at a later stage if the participant requested this. Participants had the right to refuse to answer any question or to withdraw consent at any point without coercion or pressure. If the participant became concerned or upset during the interview, staff were trained and advised to give them time and to console the participant, and then to take fresh consent before resuming the interview.

3.15 Data Storage

The research data for this study included the VA database and the linked Matlab HDSS database. The data did not contain the names of any respondents. The data files were stored in a password protected network with data back-up. Multiple copies of this database were generated and stored on a non-rewritable compact disk. The doctoral candidate and his supervisors at the Centre for International Health, School of Public Health and ICDDR,B had access to the database. The data will be retained for 5 years. Hard copies of the VA data are kept stored in the Matlab DHSS archive room, as per the standard procedure of ICDDR,B.

CHAPTER 4

Results - Neonatal Deaths and Some Associated Factors and Health Care

4.1 Introduction

This chapter describes neonatal deaths and maternal complications during pregnancy and childbirth. The results are based on the data obtained from mothers and or other respondents in relation to all neonatal deaths during 2003 and 2004 in the surveillance area, using a questionnaire especially designed for the purpose. Data collected on neonates included their birth characteristics, clinical manifestations, and consultations during the fatal illness episodes. Maternal factors examined included experiences of complications during pregnancy and delivery, and mode of delivery. Health care consultations in terms of care provider are reported according to service area, sex of newborn and age at death. The findings should direct programme managers in the planning of appropriate strategies to improve neonatal and reproductive health.

4.2 Relationship of Main Respondent to Deceased Neonate

In verbal autopsies, it is essential to collect valid and relevant information to assess the cause of death as accurately as possible. Among the many factors that might limit collection of valid information, the choice of respondent is an important consideration. In this study, the research assistant was instructed to select one main respondent who knew the deceased neonate and could reliably provide the details of illness episodes during the interview. Besides the main respondent, the help of other people was also solicited to supplement the information.

Table 4-9 shows the distribution of the main respondents in their relationship with deceased neonates. Of the 365 interviews, the mother was the main respondent in the great majority (85%) of cases. The other category of main respondent was the grand mothers (9%).

Table 4-9. Relationship of main respondent with deceased neonates

	N	(%)
Mother	309	(85)
Grandmother/grandfather	34	(9)
Father	14	(4)
Aunti/Uncle	3	(1)
Grandfather-in-law/mother-in-law	2	(1)
Sister	1	(-)
Others	2	(1)
Total	*365*	*(100)*

4.3 Neonatal Death by Maternal Complications

Mothers whose newborn died within the neonatal period were asked whether they had experienced any of the listed maternal complications around pregnancy and delivery.

Table 4-10 presents number and percentage of neonatal deaths for which the mother experienced specific complications during pregnancy and around the time of delivery. The most common complications were difficult labour and fever during the last trimester of pregnancy. A little over one-third of mothers reported that they had experienced difficult labour (36.7%) and fever (36.2%). The next most commonly reported complications were reduced foetal movement during pregnancy (27.1%) and prolonged labour (25.2%). Other common complications reported included postpartum bleeding, premature rupture of membranes, jaundice during pregnancy, umbilical cord strangulation, convulsions and breech presentations. Around one in five births resulting in neonatal death had at least one of the listed 13 specific complications, and one in seven had five or more complications (see Table 4-12).

Table 4-10. Experience of maternal complications during pregnancy or delivery

Maternal complications	**Neonatal deaths (N=365)**	
	n	**%**
Difficult labour	134	(36.7)
Fever during pregnancy	132	(36.2)
Reduced foetal movements	99	(27.1)
Prolonged labour (12+ hours)	92	(25.2)
Postpartum bleeding	71	(19.5)
Others		
Premature rupture of membrane	62	(17.0)
Jaundice during pregnancy	58	(16.0)
Umbilical cord strangulation	40	(11.0)
Antenatal bleeding	39	(11.0)
Oedema during pregnancy	23	(6.3)
Convulsions	18	(4.9)
Umbilical cord prolapse	17	(4.7)
Breech presentation	15	(4.1)
(Total neonatal death=365)		

4.4 Neonatal Signs and Symptoms During Fatal Illness Episode

Table 4-11 shows the signs and symptoms of the fatal illness episodes for all neonatal deaths. In nearly three quarters (73.4%) of the cases, neonates were reported to have decreased body movements. In 61% of cases, the newborn was cold to the touch and in 57.5%, the baby stopped crying during the fatal illness. Other frequently reported symptoms and signs included difficult breathing, fast breathing, apnoea, unusual sounding breathing, chest indrawing, unconsciousness, fever, cough, jaundice and convulsions. For more than half of the neonatal deaths, the illness episode was associated with at least five specific signs/symptoms during fatal illnesses, and around 7% had at least one of specific signs asked (see Table 4-12).

Table 4-11. Clinical signs and symptoms during the fatal neonatal illness episode

Signs and symptoms	Neonatal death (N=365) n	%
Decreased body movement	268	(73.4)
Skin cold to the touch	223	(61.1)
Stopped crying	210	(57.5)
Difficult breathing	173	(47.4)
Fast breathing	165	(45.2)
Apnea	125	(34.3)
Unusual sounding breathing	123	(33.7)
Severe chest in-drawing	104	(28.5)
Unconsciousness	91	(24.9)
Fever	56	(15.3)
Others		
Cough	37	(10.1)
Jaundice	37	(10.1)
Convulsion	36	(9.9)
Bleeding from body	30	(8.2)
Vomiting	29	(8.0)
Abdominal distension	24	(6.6)
Bulged fontanelle	6	(1.6)
Skin pustules	5	(1.4)
Liquid stools/diarrhoea	4	(1.1)

Table 4-12: Maternal complications and signs of neonatal illnesses associated with neonatal death

Number of reported complications/signs	**Maternal complications**		**Signs of Neonatal illnesses**	
	n	**%**	**n**	**%**
0	59	16.2	10	2.7
1	76	20.8	26	7.1
2	62	17.0	34	9.3
3	61	16.7	42	11.5
4	53	14.5	48	13.2
≥ 5	54	14.8	205	56.2
Total	**365**	**100**	**365**	**100**

4.5 Age at Neonatal Death

The age of death is an important consideration when designing appropriate intervention to improve neonatal survival. The bar graph below (see Figure 4-11) shows the distribution of neonatal deaths by age in days at time of death. Of the 365 neonatal deaths, 136 deaths (37.3%) occurred on the day of birth, 279 (76.4%) within the first three days, and 307 (84.1%) within the first week of life. Twenty-six (7.1%) deaths occurred during the second week, and the remaining 32 (8.8%) in the third and fourth weeks (15-28 days) of life. Thus, more than 80% of neonatal deaths occurred in the first week, with a large proportion on the day of birth.

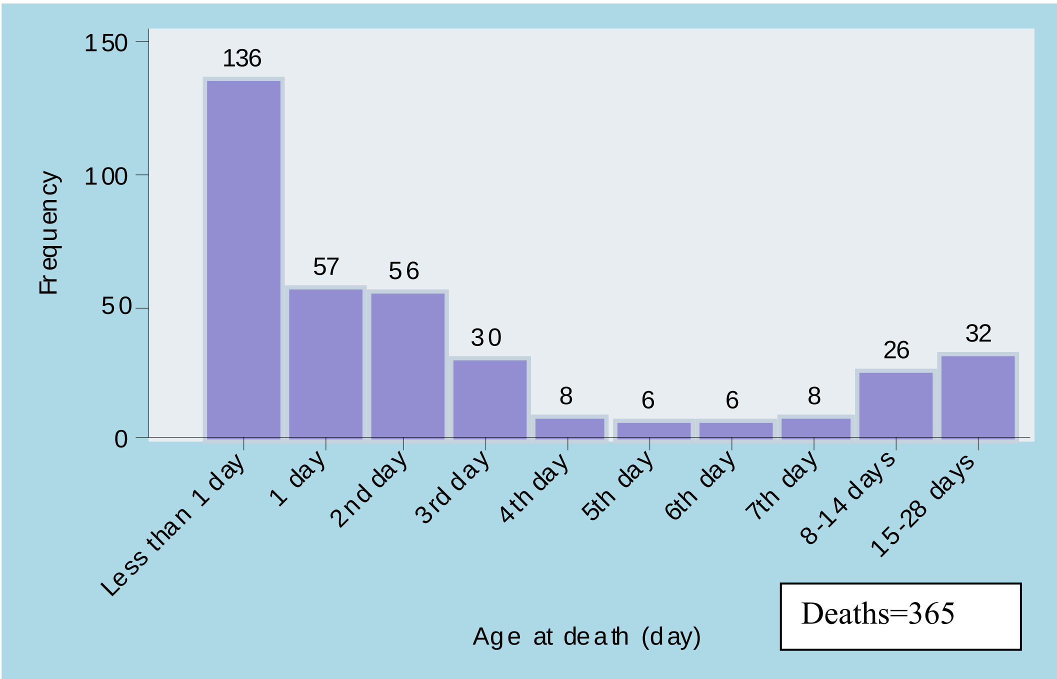


Figure 4-11. Bar graph of age at death (day)

4.6 Early and Late Neonatal Mortality Rate by Service Area

The data shows that early neonatal death was the major contributor to neonatal mortality in both service areas. Table 4-13 shows the early and late neonatal mortality rate (NMR) in the study site by service areas. The overall neonatal morality rate in Matlab was 32.3 per 1000 live births, with 30.6 in the ICDDR, B service and 34.1 in the government service area. The early neonatal morality was 28.6 per 1000 live births in the government service area, 11% higher than in the ICDDR,B service area (25.8 per 1000). The late neonatal mortality rate was 5.5 per 1000 live births in the government area, about 15% higher than in the ICDDR,B area (4.8 per 1000 live births). Overall, early neonatal deaths comprised 84% of all neonatal deaths. Death within 1 day was similar between two areas

Table 4-13. Early and late neonatal mortality by service area

Timing of deaths	**ICDDR,B Area (N=5659) Neonatal death=173**			**Government Area (N=5632) Neonatal death=192**			**Both Areas (N=11,291) Neonatal death=365**		
	n	**%**	**Rate**	**n**	**%**	**Rate**	**n**	**%**	**Rate**
Less than 1 day	66	38.2	11.7	70	36.5	12.4	136	37.3	12
Early (0-7 days)	146	84.4	25.8	161	83.9	28.6	307	84.1	27.2
Late (8-28days)	27	15.6	4.8	31	16.1	5.5	58	15.9	5.1
NMR			*30.6*			*34.1*			*32.3*

N= live births; n=neonatal death; % column percentage
Rate: neonatal deaths/1000 live births; NMR=neonatal mortality rate

4.7 Mode and Place of Delivery by Service Area

Data on mode of delivery and place of delivery are helpful in planning MCH services. Vaginal deliveries at home were the most common form of deliveries in Matlab, although there were significant differences in regards to place and mode of delivery between the two service areas.

Table 4-14 provides information on neonatal death by place and mode of delivery, as obtained from mothers during the VA. Overall, a little over three-fifths of deliveries were vaginal deliveries where no medication was used. Around 30% were vaginal deliveries where saline and labour inducing medications were used during delivery. The proportion of deliveries where medications were used was similar in both service areas (33.5% in the ICDDR,B area versus 29.2% in the government area). Around five percent (5.2%) of the deliveries required caesarian section. However, the caesarian section rate was much higher in the ICDDR,B area compared to the government area (9.3% versus 1.6%).

Overall, 64% of deliveries were conducted at home. The rate of home delivery was 51% in the ICDDR,B area and 84% in the government service area.

Table 4-14. Neonatal deaths by service area according to mode and place of delivery

	ICDDR,B		Government		Both Areas		
	n	(%)	n	(%)	n	(%)	p
Mode of delivery							
Vaginal (normal)	99	(57.2)	133	(69.3)	232	(63.6)	0.001
Vaginal (medication)	58	(33.5)	56	(29.2)	114	(31.2)	
C/S or Instrumental*	16	(9.3)	3	(1.6)	19	(5.2)	
Total	173	(100)	192	(100	365	(100)	
Place of delivery							
Home	87	(50.9)	160	(84.2)	247	(68.4)	0.001
Health facility	83	(48.5)	29	(15.3)	112	(31)	
Transit	1	(0.6)	1	(0.5)	2	(0.6)	
Total	171	(100)	190	(100)	361	100	

* There was only one instance of an instrumental delivery

4.8 Neonatal Characteristics

4.8.1 Plurality of births

The majority (82%) of deceased neonates were singleton births, while twins comprised 16% of deaths and one set of triplets accounted for 2%. Plurality of birth was not significantly different between the ICDDR,B and government service areas.

4.8.2 Birth weight

Birth weight records were available for only 119 of the 365 deaths (32.6%). The birth weights ranged from 1000 grams (g) to 4700 g, the average being 2263 g (SD 1001). The average birth weight was slightly, but not significantly, higher in newborns from the ICDDR,B area compared to the government area. The summary statistics of birth weight by service areas are shown in below.

Table 4-15. Birth weight statistics of neonatal deaths by service area

	Birth weight (gm) statistics					
Service area	**N**	**Mean**	**SD**	**Median**	**Min**	**Max**
Government	31	2152	1030	2000	1000	4500
ICDDR,B	88	2303	994	2175	1000	4700
Total	**119**	**2263**	**1001**	**2000**	**1000**	**4700**

Note: birth weights were available for only 32.6% of deaths

4.8.3 Death by low birth weight (LBW) and by service area

The majority (56%) of newborns were born with low birth weight i.e. weight below 2500 gm. LBW was slightly, but not significantly lower in the ICDDR,B area compared to the government area (55% versus 61%).

4.8.4 Perceived size of newborn at birth by service area

Figure 4-12 shows the distribution of size of newborn at birth according to service area. The respondents completing the VA were asked to describe the size of the newborn at birth by choosing one category from a set of four categories of birth size that best corresponded with their perception of the size of their deceased child. The categories were very small, smaller than usual, normal, and heavier than usual. Forty two percent of mothers in the ICDDR,B area described their deceased newborn as normal in size, the largest category, which was not significantly different to the 48% in the government serviced area.

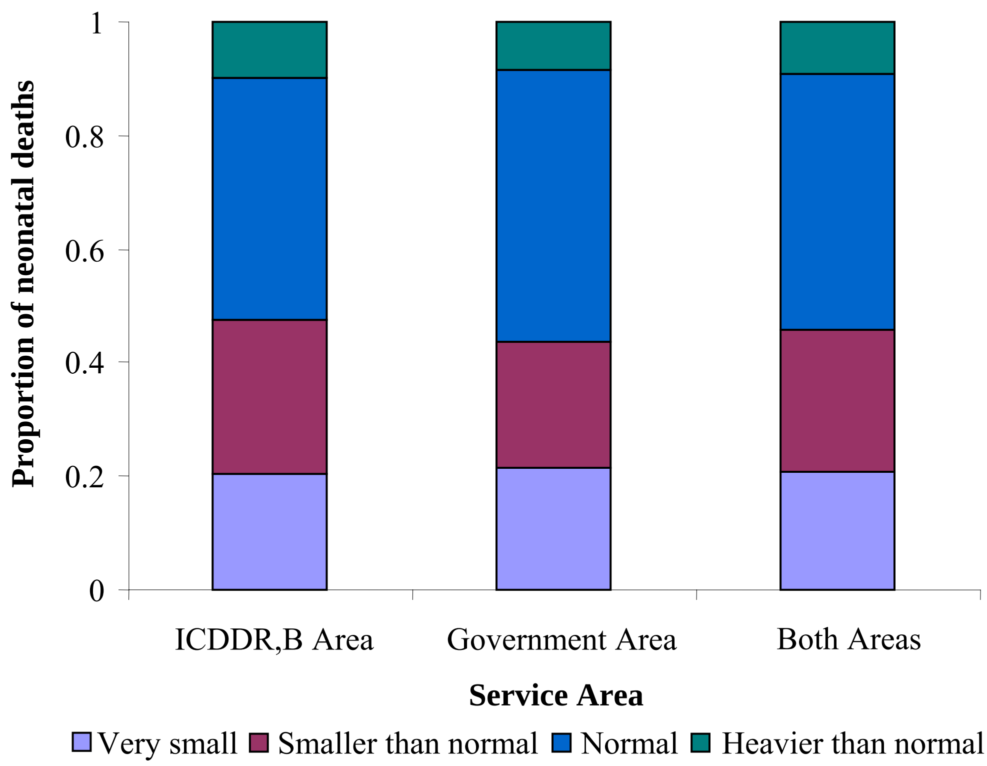


Figure 4-12: Distribution of newborn size at birth by service area

4.8.5 Relationship of perceived size with actual birth weight

Figure 4-13 shows the relationship of perceived size with actual birth weight. Mothers perceived half of the very low birth weight babies (less than 1500 g) as very small, and 40% as smaller than usual. Mother perceived of babies with birth weights 1500-1799 either as smaller than usual or normal. Babies with weights between 1800-2499 were classified as normal (71%) or smaller than normal (19%) and another 10% classified as very small. However, none of the low weight babies (less than 2500g) were perceived to be heavier than usual.

In the normal birth weight category (≥2500g), mother categorised 63% as normal followed by 29% who thought their newborns were heavier than usual. None were categorised as very small.

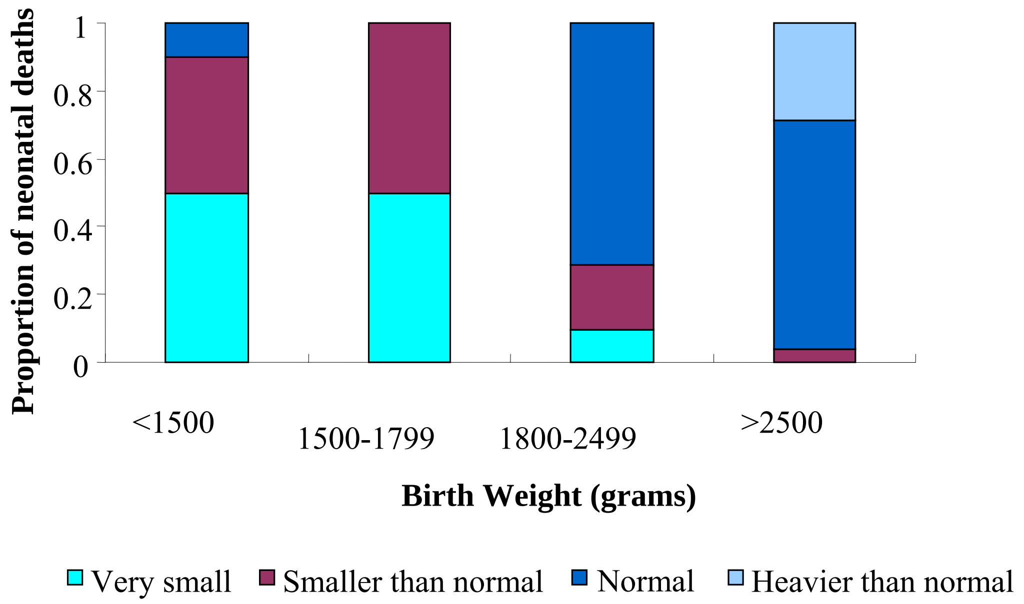


Figure 4-13: Relationship of perceived newborn size with actual birth weight

4.9 Health Care Sought During Fatal Illness Episodes

4.9.1 Health care consultation by service areas

Table 4-16 shows the distribution of health care providers consulted by the parents of deceased neonates during the fatal illness episode in both service areas.

During the terminal illness, medical doctors (23.8%) were consulted most commonly followed by paramedics (13.4%). Non-medically qualified persons involved included kabiraj (8.0%) (a village doctor who manages patient with medications derived from herbs and trees), unqualified allopath (8.0%) (an unlicensed person who uses mostly modern medicines) and homeopaths (5.8%).

Proportionately more fatal episodes were consulted with medically qualified professionals (medical doctors and paramedics) in the ICDDR,B area compared to the government area. Consultation with non-medically qualified providers (kabiraj, unqualified allopaths, homeopaths and spiritual healers) was higher in the government area than the ICDDR,B area. Pharmacies were the least utilised source of consultation for neonatal fatal illnesses in both areas. Overall, for a third of the fatal illness episodes, there were no consultations with any health care provider. This proportion was much higher in the government area (45.3%) than in the ICDDR,B area (28.9%).

Table 4-16. Health care providers during neonatal fatal illness episodes

	ICDDR,B		**Government**		**Both**	
Care provider	**N**	**(%)**	**N**	**%**	**N**	**%**
No treatment	50	(28.9)	87	(45.3)	137	(37.5)
MBBS	60	(34.7)	27	(14.1)	87	(23.8)
Paramedic	35	(20.3)	14	(7.3)	49	(13.4)
Others						
Kabiraj	11	(6.4)	18	(9.4)	29	(8.0)
Unqualified Allopaths	7	(4.1)	22	(11.5)	29	(8.0)
Homeopath	6	(3.5)	15	(7.8)	21	(5.8)
Spiritual Healer	4	(2.3)	7	(3.7)	11	(3.0)
Pharmacy	0	(0)	2	(1.0)	2	(0.6)
Total	**173**	**(100)**	**192**	**(100)**	**365**	**(100)**

4.9.2 Health care consultation by sex of newborns

Table 4-17 shows the relationship of sex of the newborn with type of health care provider consulted during the fatal illness episode. Overall, medical consultation was higher for male newborns compared to female newborns. Male newborns were more likely to have received treatment from a medically qualified source (medical doctors and paramedics) than female newborns. Consultations with non medically qualified providers (kabiraj, unqualified allopath, homeopath, and spiritual healer) were similar both for male and female newborns. Nearly, half of the female newborns (46.7%) did not receive any treatment, compared to 30% of males not receiving treatment.

Table 4-17. Health care providers according to sex of deceased neonate

	Sex of baby					
	Male		Female		Total	
Care provider	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
No treatment	60	(30.0)	77	(46.7)	137	(37.5)
MBBS	57	(28.5)	30	(18.2)	87	(23.8)
Paramedic	33	(16.5)	16	(9.7)	49	(13.4)
Others						
Unqualified allopath	17	(8.5)	12	(7.3)	29	(8.0)
Kabiraj	17	(8.5)	12	(7.3)	29	(8.0)
Homeopath	10	(5.0)	11	(6.7)	21	(5.8)
Spiritual healer	5	(2.5)	6	(3.6)	11	(3.0)
Pharmacy	1	(0.5)	1	(0.6)	2	(0.6)
Total	**200**	**(100)**	**165**	**(100)**	**365**	**(100)**

4.9.3 Health care consultation by early and late neonatal period

Table 4-18 shows the distribution of health care providers consulted according to the age at which the neonate died. The treatment/consultation patterns during fatal episodes varied by timing of death after birth. Cases of late neonatal (8-28 days) deaths were more likely to have been seen by both medically qualified providers and non-qualified providers than cases of early neonatal (0-7 days) deaths. The pharmacy was the least utilised source of care in both early and late neonatal deaths. A much higher proportion (42%) of early neonatal deaths did not receive any treatment compared to 16% of late neonatal deaths.

Table 4-18. Health care providers according to timing of death

	Age at death (day)					
	0-7		8-28		Total	
Care provider	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
No treatment	128	(41.7)	9	(15.5)	137	(37.5)
MBBS	68	(22.2)	19	(32.8)	87	(23.8)
Paramedic	46	(15.0)	3	(5.2)	49	(13.4)
Others						
Unqualified Allopath	23	(7.5)	6	(10.3)	29	(8.0)
Kabiraj	18	(5.9)	11	(19.0)	29	(8.0)
Homeopath	14	(4.6)	7	(12.1)	21	(5.8)
Spiritual healer	9	(2.9)	2	(3.5)	11	(3.0)
Pharmacy	1	(0.3)	1	(1.7)	2	(0.6)
Total	**307**	**(100)**	**58**	**(100)**	**365**	**(100)**

4.10 Multiple Consultations

The proportion of neonates who were taken for multiple consultations during the fatal illness episode was 22.2%. Such multiple consultations varied by sex, time of death and service area, as shown in Table 4-19.

4.10.1 Treatment visit by sex of newborn

Multiple consultations were more likely for male newborns than female ones. Second and third consultations were more common for males than females (19.0% and 5.0% versus 13.9% and 3.0% respectively).

4.10.2 Treatment visit by early and late neonatal period

The number of consultations varied according to the timing of newborn death. A higher proportion of late neonatal death received second and third consultations compared to early neonatal deaths. The proportion of cases with second and third consultations for late and early neonatal deaths was 25.9% and 17.2% compared to 15.0% and 1.6% respectively.

4.10.3 Treatment visits by service area

There was also variation in the number of medical consultations by service areas. Overall, a higher proportion of newborns from the ICDDR,B area received multiple consultations than those from government service areas. This finding indicates that utilization of health facilities are more in the ICDDR,B area compared to government serviced area.

Table 4-19. Number of treatment visits according to timing of death, sex and service area

		Number of treatment visits				
		0	1	2	3	>3
	N	(%)	(%)	(%)	(%)	(%)
Sex of newborn						
Male	200	(30.0)	(45.0)	(19.0)	(5.0)	(1.0)
Female	165	(46.7)	(34.6)	(13.9)	(3.0)	(1.8)
All	365	(37.5)	(40.3)	(16.7)	(4.1)	(1.4)
Timing of death						
0-7 days	307	(41.7)	(41.0)	(15.0)	(1.6)	(0.7)
8-28 days	58	(15.5)	(36.2)	(25.9)	(17.2)	(5.2)
All	365	(37.5)	(40.3)	(16.7)	(4.1)	(1.4)
Service Area						
ICDDR,B	173	(28.9)	(48.0)	(17.9)	(3.5)	(1.7)
Government	192	(45.3)	(33.3)	(15.6)	(4.7)	(1.0)
All	365	(37.5)	(40.3)	(16.7)	(4.1)	(1.4)

4.11 Summary of the Chapter

All the neonatal death cases were associated with discernible maternal or neonatal illness conditions. The great majority (84%) were associated with maternal complications during pregnancy or delivery such as difficult or prolonged labour, fever, reduced foetal movements, postpartum bleeding, premature rupture of membranes etc. Such morbidity among mothers would be expected given the high maternal mortality ratios demonstrated for Bangladesh and the lack of readily accessible and effective essential obstetric care (EOC). Thus, a reduction in neonatal mortality rates can be expected with improvements in EOC in the country.

The great majority of deaths were also associated with discernible illness or abnormal behaviour in the neonate. For example, almost three quarters of the deceased cases were observed to be listless in the days or hours prior to death, while almost two thirds were cold to the touch, and more than half stopped their usual crying. This study did not look into whether there was delayed recognition of these illness conditions by caregivers, but creating awareness of these conditions among caregivers should result in earlier and more effective health care seeking.

The high proportion of low birth weight among the cases highlights the need for better maternal nutrition and also better care of neonates with low birth weight immediately after birth. Care of the newborn is especially important given that the great majority (84%) died in the early (0-7 days) neonatal period, with more than a third dying on the first day of birth. Skilled birth attendance would be critical in providing such care during the first day of life.

Qualified medical care as a first resort of care was sought in only little more than a third of the cases, the rest receiving either traditional/unqualified care or not cares at all. Qualified care was more likely to be sought in the ICDDR,B area than in government area. This underscores the need for better education for caregivers in early recognition of danger signs and prompt care seeking from qualified sources of health care. Traditional/unqualified practitioners could be integrated into mainstream public health programmes with appropriate training and orientation.

CHAPTER 5

Results - Cause of Death and

Comparison of the Three Methods for Assigning Cause

5.1 Introduction

As described earlier, VA refers to the method of collecting and interpreting information from close family members or carers of an individual who died outside the health care system, in order to establish the cause of death. Although there are several methods available to interpret VA interview data for assigning cause of death, there are few published reports on their accuracy and reliability. This study used physician assigned causes as a reference method (where at least two physician agreeing on a cause) to compare and assess the suitability of medical assistant (MA) and algorithm approaches for interpreting VA interviews.

The chapter has three sections. Section One describes the frequency of cause of death using the reference method where at least two out of three physicians agreed on the cause of death, which is then compared across service area, sex of newborn and age at death. The level of agreement between the three physicians interpreting the same VA is also reported.

Section Two describes and compares the number and proportion of major causes of death, as determined by the three methods, namely the reference method of physician review, review by medical assistant and algorithm.

Section Three describes the evaluation of the reliability and accuracy of the two methods (medical assistant and algorithm) compared to the reference method, using statistical measures such as kappa value, sensitivity, specificity, and positive predictive value (PPV).

SECTION ONE: CAUSE OF DEATH

5.2 Cause of Death (at least two physicians agreed)

As described in Chapter 3, a cause of death was assigned based on the majority decision after independent assessment of VA data by three physicians, that is, when at least two of the three physicians agreed on a cause. This agreed cause of death was selected as the gold standard or reference diagnosis for reporting cause of neonatal death, and also used for evaluating reliability and diagnostic accuracy of MA review and algorithm assignment.

Table 5-20 shows the proportional distribution of cause of death along with 95% confidence intervals. The top five causes were birth asphyxia (44.9%), low birth weight (LBW)/prematurity (15.1%), meningitis/sepsis (12.3%), respiratory distress syndrome (RDS) (6.9%) and pneumonia (5.5%). These five causes accounted for 85% of the cases.

Other common causes included hypothermia, birth injury, sudden infant death and congenital anomalies. Around 7% of the cases were classified as undetermined as there was no agreement between any of the physicians on the cause assigned. In 1.4% of cases no cause was given by physicians.

Table 5-20. Physician assigned causes of neonatal death

Cause of death	N	%	(95% CI)	
Birth asphyxia	164	44.9	(39.8	50.2)
Prematurity/LBW	55	15.1	(11.6	19.2)
Meningitis/Sepsis	45	12.3	(9.1	16.1)
RDS	25	6.9	(4.5	9.9)
Pneumonia	20	5.5	(3.4	8.3)
Others				
Hypothermia	6	1.6	(0.6	3.5)
Birth injury	4	1.1	(0.3	2.8)
Sudden infant death	4	1.1	(0.3	2.8)
Congenital abnormality	3	0.8	(0.2	2.4)
Other specified [a]	8	2.2	(1.0	4.3)
Undetermined [b]	26	7.1	(4.7	10.3)
No cause identified	5	1.4	(0.4	3.2)
Total	**365**	**100**		

[a] congenital pneumonia (1), Neonatal aspiration syndrome (4), Congenital chickenpox (1), Neonatal jaundice (1) and neonatal hypoglycemia (1)

[b] Cause where three physicians differed on a cause of death

5.3 Associations with Cause of Death

The following sections will describe the distribution of causes of death according to a number of variables.

5.3.1 Causes of death by service area

Table 5-21 shows the distribution of cause of death by service area. Birth asphyxia (45.7%), prematurity/LBW (20.8%) and meningitis (11.6%) were the three top ranked causes of death, followed by RDS (5.8%) and pneumonia (4.6%) in the ICDDR,B service area. In the government service area, birth asphyxia (44.3%), meningitis/sepsis (13.0%) and prematurity/LBW (9.9%) were the three top causes of death, and RDS contributed 8% and pneumonia 6% as cause of death. These differences in proportions were statistically significant with the main difference being that prematurity/LBW was twice as common as a cause of death in the ICDDR,B area than in the government area (see

Table 5-21).

Table 5-21. Cause of death by service area in Matlab

	ICDDR,B		Government		Both areas	
Cause of death	**N**	**(%)**	**N**	**(%)**	**Both**	**(%)**
Birth asphyxia	79	(45.7)	85	(44.3)	164	(44.9)
Prematurity/LBW	36	(20.8)	19	(9.9)	55	(15.1)
Meningitis/Sepsis	20	(11.6)	25	(13.0)	45	(12.3)
RDS	10	(5.8)	15	(7.8)	25	(6.8)
Pneumonia	8	(4.6)	12	(6.3)	20	(5.5)
Others	20	(11.6)	36	(18.8)	56	(15.3)
Specified but rare	10	(5.8)	15	(7.8)	25	(6.8)
Undetermined	9	(5.2)	17	(8.9)	26	(7.1)
No cause	1	(0.6)	4	(2.1)	5	(1.4)
Subtotal	20	(11.6)	36	(18.8)	56	(15.3)
Total	**173**	**(100)**	**192**	**(100)**	**365**	**(100)**

Pearson $\chi^2(5) = 11.44$; $p < 0.05$

5.3.2 Cause of death by sex of newborn

Table 4-22 summarises the distribution of major cause of death by sex of the deceased neonates. The distribution by sex shows some substantial differences. Overall the number of male deaths was higher with 200 male deaths compared to 165 female deaths, with males accounting for a larger proportion of all deaths (54.8%). Birth asphyxia was the largest category of cause of death for both males and females. The following causes of death were proportionately less among females than males: birth asphyxia, prematurity/LBW, and pneumonia, while the following causes were proportionately greater among females: meningitis/sepsis, RDS and other causes. Overall, these differences in proportions of death across cause of death was significant by sex (Pearson $\chi^2(5) = 15.80$; $p < 0.01$).

Table 4-22. Cause of death by sex of deceased neonate

Cause of death	Male		Female		Both	
	N [a]	**(%)**	**N**	**(%)**	**N**	**(%)**
Birth asphyxia	102	(51.0)	62	(37.6)	164	(44.9)
Prematurity/LBW	31	(15.5)	24	(14.5)	55	(15.1)
Meningitis/Sepsis	20	(10.0)	25	(15.2)	45	(12.3)
Pneumonia	14	(7.0)	6	(3.6)	20	(5.5)
RDS	13	(6.5)	12	(7.3)	25	(6.8)
Others	20	(10.0)	36	(21.8)	56	(15.3)
Specified (rare)	10	(5.0)	15	(9.1)	25	(6.8)
Undetermined	9	(4.5)	17	(10.3)	26	(7.1)
No cause	1	(0.5)	4	(2.4)	5	(1.4)
Total	**200**	**(100)**	**165**	**(100)**	**365**	**(100)**
Pearson $\chi^2(5) = 15.80$; p<0.01						

[a] includes specified but small number causes and undetermined causes of death

5.3.3 Cause of death by early and late neonatal period

There were major differences in the distribution of causes of death by early and late neonatal periods (see Table 5-23). The majority of neonatal deaths (84.1%) occurred within the first week after birth. Birth asphyxia (52.8%) was the single largest category of cause of death in early neonatal deaths, while meningitis/sepsis (48.3%) was the single largest category for late neonatal deaths. Of the total number of deaths that occurred in the early neonatal period compared to the late neonatal period, a high proportion could be attributed to birth asphyxia, prematurity/LBW, RDS, and a lower proportion to meningitis/sepsis, pneumonia and other causes. These differences by categories of cause of death between the early and late neonatal period were statistically significant (Pearson $\chi^2(5) = 30.95$; p<0.01; Fisher's exact p=0.001).

Table 5-23. Cause of death by early and late neonatal period

	Early (0-7 days)		Late (8-28 days)		Both period	
Cause of death	**N**	**%**	**N**	**%**	**N**	**%**
Birth asphyxia	162	(52.8)	2	(3.4)	164	(44.9)
Prematurity/LBW	52	(16.9)	3	(5.2)	55	(15.1)
RDS	24	(7.8)	1	(1.7)	25	(6.8)
Meningitis/Sepsis	17	(5.5)	28	(48.3)	45	(12.3)
Pneumonia	9	(2.9)	11	(19.0)	20	(5.5)
Others	43	(14.0)	13	(22.4)	56	(15.3)
Specified (rare)	19	(6.2)	6	(10.3)	25	(6.8)
Undetermined	20	(6.5)	6	(10.3)	26	(7.1)
No cause	4	(1.3)	1	(1.7)	5	(1.4)
Total	**307**	**(100)**	**58**	**(100)**	**365**	**100**

Fisher's exact p=0.001

5.4 Agreement Between Physicians

Inter-rater variation is an important criterion for judging the quality of the method for assigning cause of death. One way of measuring variation is to compare the diagnoses made by three physicians involved in interpreting neonatal VA interview data shown in Table 5-24 below. As can be seen from the table, in 51% of cases two physicians agreed and in 42% of cases all three physicians agreed on the cause of deaths. In all, there was agreement by at least 2 physicians in 93% of cases leaving only 7% of cases where there was no agreement between any two of the physicians.

Table 5-24. Agreement between physicians interpreting the same VA reports

Level of physician agreement	Neonatal deaths (N=365) n	%
No agreement	26	(7.1)
Two physicians agreed on a cause	187	(51.2)
Three physicians agreed on a cause	152	(41.6)
At least two physicians agreed	339	(92.9)
Total deaths=365		

SECTION TWO: COMPARISON OF MAJOR CAUSES OF DEATH BY METHODS

This section compares the three methods in assigning causes of deaths. Table 5-25 shows the comparative magnitude of the main causes of death as ascertained by the three methods.

5.5 Comparison of Cause of Death According to Methods

5.5.1 Death due to prematurity/low birth weight

The algorithm is based on predefined criteria with the hierarchy, and assigned 20% of cases as having prematurity/low birth weight as a cause of death, the corresponding percentages of physician1 and physician2 were 18 and 16 respectively. Physician3 assigned only 8% cases to prematurity/low birth weight. The MA assignation was 11%.

5.5.2 Death due to birth asphyxia

Birth asphyxia was the most frequent cause of death. The algorithmic method assigned this cause to 40% of all deaths, the MA to 42% of cases, while physicians ranged from 39 to 53% of the cases.

5.5.3 *Death due to respiratory distress syndrome (RDS)*

The algorithm classified 8% of cases as RDS, the MA classified 11%, while the physicians ranged from 4 to 13% in their classification of cases as RDS.

5.5.4 *Death due to pneumonia*

For the algorithm, cause of death was classified as 7% for pneumonia and the corresponding pneumonia percentages for physician1 and physician2 were six and seven respectively. Physician3 assigned the lowest percentages (3.6%) and MA assigned the highest proportion (9.6%) compared with other methods. Thus, physician3 and MA assessment differed most for pneumonia classification, and other methods had a reasonable agreement (see Table 5-25).

5.5.5 *Death due to meningitis/sepsis*

While algorithm assigned 13% cases as meningitis/sepsis, the corresponding percentage for physician1 and physician2 were 16 and 9 respectively. Physician3 assigned 20% cases and it was the highest among the methods. The MA assigned 8% cases as death due to meningitis/sepsis and it was the lowest figure among other methods. To conclude, there was a reasonable agreement between algorithm and physician1; also between MA and physician2. Physician3 assessment varied most for meningitis/sepsis classification (see Table 5-25).

Table 5-25. Major cause of death by different methods

		Prematurity/low birth weight		Birth asphyxia		RDS		Pneumonia		Meningitis/Sepsis		Total
Review Methods	**Total**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**	**Row (%)**
Algorithm	365	71	(19.5)	146	(40.0)	29	(7.9)	27	(7.4)	49	(13.4)	(88.2)
Physician1	365	64	(17.5)	151	(41.4)	23	(6.3)	22	(6.0)	57	(15.6)	(86.8)
Physician2	365	59	(16.2)	141	(38.6)	49	(13.4)	26	(7.1)	33	(9.0)	(84.3)
MA	364	41	(11.3)	151	(41.5)	39	(10.7)	35	(9.6)	29	(8.0)	(81.1)
Physician3	365	29	(7.9)	194	(53.2)	13	(3.6)	13	(3.6)	72	(19.7)	(88.0)

5.6 Major Cause-specific Mortality Fraction of Methods

Table 5-26 summarises cause of death by physician method (at least two physicians agreeing on a cause), MA and algorithm method for assigning cause of death. As can be seen, both MA and algorithm assigned a slightly smaller proportion of deaths to birth asphyxia compared to the physician method (41.5% and 40% respectively versus 44.9%). For prematurity/low birth weight, MA assigned a smaller proportion of deaths (11.3%) while algorithm assigned a higher proportion of deaths (19.5%) due to this cause, compared to the physician method (15.1%). There were small variations for the other causes of deaths as well, such as meningitis/sepsis, RDS and pneumonia.

Table 5-26. Cause-specific mortality fraction of physician (at least two physicians agreed), medical assistant and algorithm approach

	Physician		**MA**		**Algorithm**	
Cause of death	**N**	**%**	**N**	**%**	**N**	**%**
Birth asphyxia	164	(44.9)	151	(41.5)	146	(40.0)
Prematurity/LBW	55	(15.1)	41	(11.3)	71	(19.5)
Meningitis/Sepsis	45	(12.3)	29	(8.0)	49	(13.4)
RDS	25	(6.9)	39	(10.7)	29	(8.0)
Pneumonia	20	(5.5)	35	(9.6)	27	(7.4)
Others						
Neonatal tetanus	0	(0)	0	(0)	8	(2.2)
Congenital anomaly	3	(0.8)	10	(2.8)	13	(3.6)
Diarrhoea	0	(0)	0	(0)	4	(1.1)
Specified rare[a]	22	(6.0)	57	(15.7)	0	(0)
Undetermined [b]	26	(7.1)	n/a	n/a	n/a	n/a
No cause	5	(1.4)	2	(0.6)	18	(4.9)
Total	**365**	**(100)**	**364**	**(100)**	**365**	**(100)**

[a] Categories with small number are grouped under other specified.
[b] Cause where three physicians' differed on a cause of death

SECTION THREE: EVALUATION OF RELIABILITY AND ACCURACY

5.7 Agreement Between Three Physicians and MA

Inter method and inter-rater variation (percent agreement) is important in evaluating a method for its routine use for assigning causes of death. Table 5-27 presents percentage agreement for which the MA agreed with a specific physician individually as well as with the combination of physicians for assigning a cause of death. In the great majority of cases (81.6%), there was agreement between the MA and at least one physician on a cause of death. Agreement between the MA and two physicians occurred in 63% of cases, and between the MA and three physicians in 37% of cases. The levels of agreement in assigning causes between the MA and any particular physician were varied, with 61% agreement with physician1, 67% with physician2 and 54% with physician3. There was no agreement reached between the MA and any of the physicians in 18% of the cases (see Table 5-27).

Table 5-27. Agreement between MA and three physicians interpreting same VA reports

Agreement between MA and physicians	deaths=365	
	n	**%**
MA agreed with physician1	223	(61.1)
MA agreed with physician2	243	(66.6)
MA agreed with physician3	198	(54.3)
No agreement between MA and physicians	67	(18.4)
MA agreed with one physician	68	(18.6)
MA agreed with two physicians	94	(25.8)
MA agreed with all three physicians	136	(37.3)
MA agreed at least with one physician	298	(81.6)
MA agreed at least with two physicians	230	(63.0)

5.8 Reliability (Kappa Score) Between Individual Physician & MA

Percent agreements with the associated kappa values for the physicians and MA methods are shown in Table 5-28. Overall, the percentage agreement between each of the physicians and the MA was reasonably high for the five major causes of death (81% to 94%). The corresponding kappa values ranged from moderate to good for all the agreements between the MA and physician1 and physician2 except for that between the MA and physician1 for meningitis/sepsis (0.36). The degree of agreement between the MA and physician3 varied and the corresponding kappa values indicated a good strength of agreement for birth asphyxia (0.63), moderate strength to meningitis/sepsis (0.44), and fair strength of agreement (0.27-0.31) for the other three major categories of deaths.

Table 5-28. Agreement between physicians and MA for assigning cause of death

	Physician1 & MA		**Physician2 & MA**		**Physician3 & MA**	
Cause of death	**PA**	**kappa**	**PA**	**kappa**	**PA**	**kappa**
Birth asphyxia	89.6	0.79	87.9	0.75	81	0.63
Prematurity/LB	87.7	0.50	90.1	0.58	87.9	0.31
WRDS	91.8	0.47	93.4	0.69	90.1	0.27
Pneumonia	92	0.45	94.2	0.63	91.8	0.34
Sepsis/Meningitis	86.5	0.36	92.9	0.54	86.3	0.44

PA –percent agreement

5.9 Reliability Between Individual Physician and Algorithm

The percentage agreement with the associated kappa values for the physician and algorithm are shown in Table 5-29.. Like physician and MA agreement, there was a similar level of agreement between the physicians and algorithm, although the degree of agreement varied more for different causes of death, with meningitis/sepsis rating relatively less high than the other causes between the algorithm and physician1 and physician2. The corresponding kappa values for birth asphyxia indicated good strength of agreement between the physicians and algorithm, but weak to moderate strength of agreement for the other causes.

Table 5-29. Agreement between individual physician and algorithm for assigning cause of death

Cause of death	Physician1 & Algorithm		Physician2 & Algorithm		Physician3 & Algorithm	
	PA	**kappa**	**PA**	**kappa**	**PA**	**kappa**
Birth asphyxia	85.5	0.70	84.4	0.67	81.4	0.63
RDS	92.3	0.42	85.8	0.26	91.2	0.20
Prematurity/LBW	82.2	0.41	81.4	0.37	81.9	0.26
Pneumonia	92.1	0.37	93.2	0.49	94.5	0.47
Meningitis/sepsis	78.6	0.14	85.2	0.26	78.9	0.24

PA –percent agreement

5.10 Diagnostic Accuracy and Reliability of MA and Algorithm

Using physician review (with agreement on a cause from at least two physicians) as the reference method, the diagnostic accuracy of the two methods (medical assistant review and algorithm) were examined. Sensitivity, specificity, positive predictive value and negative predictive values were estimated for the methods for each of the major causes.

Sensitivity- If the MA or algorithm method has a high sensitivity; it indicates a low false-negative rate. In the context of the study, this would mean that the rate of misclassification or wrong diagnosis by the MA or algorithm method was low.

Specificity- A high specificity indicates a low false-positive rate. This would mean a low likelihood of a MA or algorithm method to wrongly assign a cause where there was no such cause present.

Positive predictive value (PPV) of test/method- If a test or method has a high PPV; it implies a low false-positive rate. This would mean that the MA or algorithm method did not erroneously assign a cause where such a cause was not present.

Negative predictive value (NPV)- If a test or method has a high NPV, it implies a low false-negative rate. This would mean that a MA or algorithm method did not erroneously assign the absence of a cause where such a cause was actually present.

5.10.1 Prematurity/low birth weight

Table 5-30 shows the diagnostic accuracy of MA review in assigning prematurity/low birth weight as a cause of death. The method had high specificity (96%) but poor sensitivity (53%). The poor sensitivity implies that MA would not classify the deaths of a high proportion (47%) of cases as death due to prematurity/low birth weight where the physicians regarded prematurity/low birth weight to be the cause of death. The positive predictive value of 71% indicates that in 29% of cases, the physician method did not agree with the MA diagnosis.

Table 5-30. Diagnostic accuracy and reliability of the medical assistant review compared to physician agreement for assigning cause of neonatal death as prematurity/LBW

Physician	**Medical Assistant**		
Prematurity/LBW	**Yes**	**No**	**Total**
Yes	29	26	55
No	12	297	309
Total	41	323	364
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	52.7	(38.8	66.3)
Specificity	96.1	(93.3	98.0)
Positive predictive value	70.7	(54.5	83.9)
Negative predictive value	92.0	(88.4	94.7)
Reliability statistics	**PA**	**EA**	**kappa**
	89.6	77.0	0.55

95% CI: confidence interval; PA= percent agreement; EA= expected agreement

Table 5-31 shows the diagnostic accuracy of algorithmic method in assigning prematurity/low birth weight as a cause of death. As can be seen, the sensitivity and specificity were roughly similar to the MA method. However, the predictive ability was much poorer compared to the MA method (42% versus 71%), implying that in more than half of the cases (58%), the physician method did not agree with the algorithmic diagnosis.

Table 5-31. Diagnostic accuracy and reliability of the algorithm compared to physician agreement for assigning cause of neonatal death as prematurity/LBW

Physician	**Algorithm**		
Prematurity/LBW	**Yes**	**No**	**Total**
Yes	30	25	55
No	41	269	310
Total	71	294	365
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	54.5	(40.6	68.0)
Specificity	86.8	(82.5	90.3)
Positive predictive value	42.3	(30.6	54.6)
Negative predictive value	91.5	(87.7	94.4)
Reliability statistics	**PA**	**EA**	**kappa**
	81.9	71.3	0.37

The agreement between physician and MA review approach was moderate (k=0.55), but agreement between physician and algorithm approach was fair (k=0.37) for assigning prematurity/low birth weight as cause of neonatal death (see Table 5-30 & Table 5-31).

5.10.2 Birth asphyxia

Table 5-32 shows the diagnostic accuracy of MA review in assigning birth asphyxia as a cause of neonatal death. As can be seen, the method had reasonably good sensitivity, specificity and predictive values.

Table 5-32. Diagnostic accuracy and reliability of the medical assistant review compared to physician agreement for assigning cause of neonatal death as birth asphyxia

Physician	Medical Assistant		
Birth asphyxia	**Yes**	**No**	**Total**
Yes	137	27	164
No	14	186	200
Total	151	213	364
Diagnostic accuracy	%	(95%CI)	
Sensitivity	83.5	(77.0	88.9)
Specificity	93.0	(88.5	(96.1)
Positive predictive value	90.7	(84.9	(94.8)
Negative predictive value	87.3	(82.1	(91.5)
Reliability statistics	**PA**	**EA**	**Kappa**
	88.7	50.8	0.77

Table 5-33 shows the diagnostic the accuracy of algorithm method in assigning birth asphyxia as a cause of death. While the sensitivity, specificity and predictive values were also reasonably good, they did not quite approach the values observed with the MA review in assigning birth asphyxia as a cause of death.

Table 5-33. Diagnostic accuracy and reliability of the algorithm compared to physician agreement for assigning cause of neonatal death as birth asphyxia

Physician	Algorithm		
Birth asphyxia	**Yes**	**No**	**Total**
Yes	127	37	164
No	19	182	201
Total	146	219	365
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	77.4	(70.3	83.6)
Specificity	90.5	(85.6	94.2)
Positive predictive value	87.0	(80.4	92.0)
Negative predictive value	83.1	(77.5	87.8)
Reliability statistics	**PA**	**EA**	**kappa**
	84.7%	51.0%	0.69

The agreement was good for between physician and MA review (k=0.77) and for between physician and algorithm approach (k=0.69) for assigning birth asphyxia as cause of neonatal death (see Table 5-32 & Table 5-33).

5.10.3 Respiratory distress syndrome (RDS)

Table 5-34 shows the diagnostic accuracy of MA review in assigning RDS as a cause of neonatal death. The method had good specificity (94.4%) but the sensitivity was lower at 80%. The positive predictive value was also quite low at 51%, indicating that in 49% of cases, the consensus of physicians' review did not agree with the diagnosis made by the MA after review of the same information.

Table 5-34. Diagnostic accuracy and reliability of the medical assistant review compared to physician agreement for assigning cause of neonatal death as Respiratory Distress Syndrome (RDS)

Physician	**Medical Assistant**		
RDS	**Yes**	**No**	**Total**
Yes	20	5	25
No	19	320	339
Total	39	325	364
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	80.0	(59.3	93.2)
Specificity	94.4	(91.4	96.6)
Positive predictive value	51.3	(34.8	67.6)
Negative predictive value	98.5	(96.4	99.5)
Reliability statistics	**PA**	**EA**	**kappa**
	93.4	83.9	0.59

Table 5-35 shows the diagnostic accuracy of the algorithm method for assigning RDS as a cause of death. The method had poor sensitivity at 40%, although the specificity was good at 94%. The predictive value was also very low at 35%.

Table 5-35. Diagnostic accuracy and reliability of algorithm approach compared to physician agreement for assigning cause of neonatal death as Respiratory Distress Syndrome (RDS)

Physician	**Algorithm**		
RDS	**Yes**	**No**	**Total**
Yes	10	15	25
No	19	321	340
Total	29	336	365
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	40.0	(21.1	61.3)
Specificity	94.4	(91.4	96.6)
Positive predictive value	34.5	(17.9	54.3)
Negative predictive value	95.5	(92.7	97.5)
Reliability statistic	**PA**	**EA**	**kappa**
	90.7	86.3	0.32

The agreement for RDS as cause of death was good between physician and MA review (k=0.59), but between the physician and algorithm approach it was only fair (k=0.32) (see Table 5-34 & Table 5-35).

5.10.4 Pneumonia

Table 5-36 shows the diagnostic accuracy of the MA review in assigning pneumonia as a cause of neonatal death. The method had good specificity (94%) and fair sensitivity (75%). The positive predictive value was poor at 43%.

Table 5-36. Diagnostic accuracy and reliability of the medical assistant review compared to physician agreement for assigning cause of neonatal death as pneumonia

Physician	**Medical Assistant**		
Pneumonia	**Yes**	**No**	**Total**
Yes	15	5	20
No	20	324	344
Total	35	329	364
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	75.0	(50.9	91.3)
Specificity	94.2	(91.2	96.4)
Positive predictive value	42.9	(26.3	60.6)
Negative predictive value	98.5	(96.5	99.5)
Reliability statistics	**PA**	**EA**	**kappa**
	93.1	86.0	0.51

Table 5-37 shows the diagnostic accuracy of the algorithm method in assigning pneumonia as a cause of neonatal death. While the specificity remained high (96%), the sensitivity (65%) was poorer than with the MA review. The positive predictive value was low at 48%.

Table 5-37. Diagnostic accuracy and reliability of the algorithm compared to physician agreement for assigning cause of neonatal death as pneumonia

Physician	**Algorithm**		
Pneumonia	**Yes**	**No**	**Total**
Yes	13	7	20
No	14	331	345
Total	27	338	365
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	65.0	(40.8	84.6)
Specificity	95.9	(93.3	97.8)
Positive predictive value	48.1	(28.7	68.1)
Negative predictive value	97.9	(95.8	99.2)
Reliability statistic	**PA**	**EA**	**kappa**
	94.2	87.9	0.52

The agreement as measured by kappa statistic was graded “moderate”, both for that between physician and MA review (k=0.51) and between physician and algorithm method (k=0.52) for assigning pneumonia as a cause of neonatal death (see Table 5-36 & Table 5-37).

5.10.5 Sepsis/Meningitis

Table 5-38 shows the diagnostic accuracy of MA review in assigning meningitis/sepsis as a cause of neonatal death. The method had high specificity of almost 98%, while sensitivity was poor at 48%. The positive predictive value was relatively good at 72% and the negative predictive value was high at 93%.

Table 5-38. Diagnostic accuracy and reliability of the medical assistant review compared to physician agreement for assigning cause of neonatal death as sepsis/meningitis

Physician	**Medical Assistant**		
Sepsis/Meningitis	**Yes**	**No**	**Total**
Yes	21	23	44
No	8	312	320
Total	29	335	364
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	47.7	(32.5	63.3)
Specificity	97.5	(95.1	98.9)
Positive predictive value	72.4	(52.8	87.3)
Negative predictive value	93.1	(89.9	95.6)
Reliability statistics	**PA**	**EA**	**kappa**
	91.5	81.9	0.53

The algorithm performed poorly compared to the MA review in assigning meningitis/sepsis as a cause of death. As Table 5-39 shows, the sensitivity was only 36%, while the specificity was 90%. The PPV was only 30%, while the NPV approached a high at 91%.

Table 5-39. Diagnostic accuracy and reliability of the algorithm compared to physician agreement for assigning cause of neonatal death as sepsis/meningitis

Physician	**Algorithm**		
Sepsis/Meningitis	**Yes**	**No**	**Total**
Yes	16	29	45
No	33	287	320
Total	49	316	365
Diagnostic accuracy	**%**	**(95% CI)**	
Sensitivity	35.6	(21.9	51.2)
Specificity	89.7	(85.8	92.8)
Positive predictive value	29.8	(18.4	43.4)
Negative predictive value	90.9	(87.1	93.9)
Reliability statistic	**PA**	**EA**	**kappa**
	83.0	77.6	0.24

The agreement between physician and MA review approach was moderate between the physicians and MA review (k=0.53), while the agreement between the physicians and algorithm (k=0.24) was fair for assigning meningitis/sepsis as a cause of neonatal death (see Table 5-38 & Table 5-39).

5.11 Summary of Reliability and Accuracy Between Methods

Table 5-40. Summary diagnostic accuracy and reliability of medical assistant and algorithm compared to physician agreement for assigning major causes of death

		Diagnostic accuracy			Reliability	
Condition	**Review Method**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**Kappa**	**Strength of agreement**
Prematurity/ LBW	MA	52.7	96.1	70.7	0.55	Moderate
	Algorithm	*54.5*	*86.8*	*42.3*	*0.37*	*Fair*
Birth asphyxia	MA	83.5	93.0	90.7	0.77	Good
	Algorithm	*77.4*	*90.5*	*87.0*	*0.69*	*Good*
RDS	MA	80.0	94.4	51.3	0.59	Moderate
	Algorithm	*40.0*	*94.4*	*34.5*	*0.32*	*Fair*
Pneumonia	MA	75.0	94.2	42.9	0.51	Moderate
	Algorithm	*65.0*	*95.9*	*48.1*	*0.52*	*Moderate*
Sepsis/ meningitis	MA	47.7	97.5	72.4	0.53	Moderate
	Algorithm	*35.6*	*89.7*	*29.8*	*0.24*	*Fair*

Agreement between the MA and physicians for major causes of death appeared to have a good strength of agreement for birth asphyxia and a moderate agreement for prematurity/low birth weight, RDS, pneumonia and meningitis/sepsis. The hierarchical algorithm, also had good agreement for birth asphyxia and moderate agreement for pneumonia, but it had fair agreement for other three major categories of cause of death.

For accuracy assessment, considering two physician agreement as the reference category, MA had a high level of sensitivity (>50%) and specificity (>90%) for assigning major cause of death except for meningitis/sepsis where the sensitivity was 48%. MA had also a high level of PPV (>70%) for assigning same cause of death as the physician for birth asphyxia, prematurity/low birth weight, and sepsis/meningitis, although the PPV for pneumonia and RDS were a bit low but within a reasonable range (43-51%).

The hierarchical algorithm worked well for birth asphyxia and had moderate agreement for pneumonia diagnosis, but the performance was only fair for prematurity/low birth weight, RDS and meningitis/sepsis categories as causes of death. The algorithm had a high level of specificity for all categories but had a low sensitivity for RDS, sepsis/meningitis and a reasonable sensitivity (>50%) for birth asphyxia (77%), prematurity/low birth weight (55%) and pneumonia (65%). Similarly PPV was also low for four of the five major causes of death categories, the exception being birth asphyxia where it was 87% (see Table 5-40).

5.12 Summary of the Chapter

In using physicians to assign cause of death from the VA data, there was a very high proportion (93%) of neonatal deaths where at least two physicians agreed, enabling a cause of death to be assigned as per the a priori design of the study. In the remaining seven percent of cases, the physicians did not agree on the cause of death. The great majority of deaths could be attributed to birth asphyxia, prematurity/low birth weight, respiratory distress syndrome (RDS), pneumonia and meningitis/sepsis. These are largely preventable conditions when there is attendance by skilled birth assistants and with neonatal resuscitation and appropriate neonatal care, and underscore the need to build capacity in these capabilities for rural districts in Bangladesh.

Overall, in terms of reliability and diagnostic accuracy to assign cause of death, the medical assistant performed better than the hierarchical algorithm. However, for certain causes such as birth asphyxia and pneumonia, the hierarchical algorithm was as reliable as the medical assistant. In terms of diagnostic accuracy, the medical assistant was also more sensitive and specific than the hierarchical algorithm for most causes, except for birth asphyxia where algorithms were both highly sensitive and specific in accurately diagnosing the condition. In the absence of a medically confirmed cause of death, because physicians are scarce in rural areas, both a medical assistant and/or a computer algorithm could be used to assign cause of death. Unfortunately, the study was not designed to assess the use of combining medical assistant with the algorithm in assigning cause of death, and this is an area that could be considered for future research. However, the proportion of a specific cause of death will vary with the placement of specific category within the hierarchy of the algorithm. This is because of overlapping clinical features of neonatal illness.

CHAPTER 6
Results - Predictors of Neonatal Mortality

6.1 Introduction

This chapter describes the distribution of demographic, reproductive and birth characteristics of live births, including those that terminated in neonatal deaths. Statistics relating to predictors for neonatal mortality are also presented.

Binary logistic regression for unadjusted and adjusted odds ratio (OR) was performed on 13 explanatory variables for neonatal mortality. The 13 predictor/explanatory variables were:

Maternal demographic characteristics -

1) Age
2) Religion
3) Education
4) Occupation
5) Parity

Maternal reproductive characteristics -

6) Antenatal care (ANC) use during first trimester
7) Antenatal care (ANC) use during last trimester
8) Place of delivery
9) Service area

Newborn's birth characteristics -

10) Birth month
11) Birth year
12) Sex of newborn
13) Plurality of births

Live births and neonatal deaths

Generally, total live births are used as the denominator when calculating infant and neonatal mortality. In this study, a live birth was defined if the mother reported that the newborn had made a sound or cried, breathed or moved at birth.

In the calculation of total live births in this study, twin pregnancies were counted as two live births and triplet pregnancy as three live births.

6.2 Live Births and Incomplete Records

Table 6-41 shows the distribution of live births and neonatal deaths by plurality of birth. Of 11,291 live births accessed from the Matlab HDSS database, 11,055 (98.6%) had complete information on all variables considered to be potential predictors of neonatal mortality. Among live births, 98% of single births and 96% of twin births had complete information (see Table 6-41).

Table 6-41. Completeness of live births and neonatal death records by plurality of births

	Live births			**Neonatal deaths**		
		Incomplete records			**Incomplete records**	
Plurality	**Total**	**n**	**(%)**	**Total**	**n**	**(%)**
Single	11072	228	(2.1)	303	11	(3.6)
Twin	216	8	(3.7)	59	2	(3.4)
Triplet	3	0	(0.0)	3	0	(0.0)
Grand total	11291	236	(2.1)	365	13	(3.6)

Neonatal deaths

Of all live births, 365 died (3.2%) within the neonatal period. These consisted of 303 singleton deaths, 59 twin deaths and 3 triplet deaths. Of these, records were incomplete for 11 singleton and 2 twin deaths (see Table 6-41).

6.3 Neonatal Mortality Rate (NMR)

Neonatal death refers to death within the first 28 days of life and the neonatal mortality rate (NMR) is the number of neonatal deaths for every one thousand live births.

As described in Table 6-42, the neonatal mortality rate in Matlab during the two year period (2003-2004) averaged 32.3 deaths per 1000 live births. This is slightly less than the global average of 36 deaths per 1000 live births and the Bangladeshi national average of 41 deaths per 1000 live births (Yu 2003; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). The variations in NMR by plurality of births were substantial. The study sample included three live births from one triplet pregnancy, all of whom died during the neonatal period. The NMR for twin births was 10 times higher than the NMR for singleton births (273.1 deaths/1000 live births vs. 27.4 deaths/1000 live births).

Table 6-42. Neonatal mortality rate (NMR) by plurality of births

		Neonatal deaths	
Plurality	**Live births**	**n**	**NMR (per 1000 live births)**
Single	11,072	303	(27.4)
Twin	216	59	(273.1)
Triplet	3	3	(1000)
Total	11,291	365	(32.3)

6.4 Analysis of Singleton Live Births

6.4.1 Covariates of mortality in singleton births

Odds ratios estimate relative risk and quantify the magnitude of the relationship between a specific risk category and a reference category. In the following, the odds ratio are the ratio of the odds of neonatal death in a given risk category to the odds of neonatal dead in the reference category. Logistic regression was performed to assess the predictor ability of explanatory variables on neonatal mortality.

6.4.2 Maternal demographic covariates

Table 6-43 shows the distribution of maternal demographic characteristics among singleton births and neonatal deaths during 2003-2004. The purpose of this table is to identify factors likely to have an impact on neonatal survival.

Maternal age

Maternal age was grouped into five age categories. A third (33%) of the mothers was aged 20-24 years, of these 2.6% lost their newborns within 4 weeks. The neonatal mortality was highest in mothers younger than 20 years who comprised 13.4% of the sample, but of whom 3.8% lost their newborns. Mothers above 40 years comprised 1.6%, and of these 2.9% lost their babies. Mothers between 25-29 years of age comprised a quarter of the sample (26%) and of these 2.3% lost their newborns.

Using the age group 20-24 years as the reference category, mothers below 20 years were associated with a statistically significant 47% excess risk of losing their newborns (OR 1.47; 95%CI:1.05-2.06 ;p=0.026). Odds ratios for other categories of maternal ranged from 0.90 to 1.11, with none reaching statistical significance (see Table 6-43).

Table 6-43. Maternal demographic covariates of singleton live births and neonatal mortality

Demographic	Singleton live births (N=10844)*		Live births resulting in Neonatal Death		Crude			
					OR	*(95% CI)*		Overall p-value
Age	n	*%*	n	*NMR*[a]				
<20	1,453	*(13.4)*	55	*(38)*	1.47	*(1.05*	*2.06)*	0.17
20-24	3,569	*(32.9)*	93	*(26)*	1.00			
25-29	2,853	*(26.3)*	67	*(23)*	0.90	*(0.65*	*1.24)*	
30-34	1,985	*(18.3*	53	*(27)*	1.03	*(0.73*	*1.44)*	
35-39	810	*(7.5)*	19	*(23)*	0.90	*(0.54*	*1.48)*	
≥40	174	*(1.6)*	5	*(29)*	1.11	*(0.44*	*2.76)*	
Religion								
Muslim	9,829	*(90.6)*	257	*(26)*	1.00			
Hindu	1,015	*(9.4)*	35	*(34)*	1.33	*(0.93*	*1.91)*	0.13
Education								
None	2,649	*(24.4)*	82	*(31)*	1.32	*(0.99*	*1.77)*	0.05
1-5years	2,954	*(27.2)*	90	*(30)*	1.30	*(0.98*	*1.72)*	
6-10years	4,794	*(44.2)*	113	*(24)*	1.00			
≥11years	447	*(4.1)*	7	*(16)*	0.66	*(0.31*	*1.42)*	
Occupation								
Housewife	9,331	*(86.0)*	253	*(27)*	1.00			
Others	1,513	*(14.0)*	39	*(26)*	0.95	*(0.67*	*1.34)*	0.77
Parity								
1	3,863	*(35.6)*	142	*(37)*	1.79	*(1.41*	*2.29)*	0.001
2-4	6,004	*(55.4)*	125	*(21)*	1.00			
≥ 5	977	*(9.0)*	25	*(26)*	1.24	*(0.80*	*1.91)*	
Total	10,844	*(100)*	292	*(27)*				

Note: Cases where no data was missing; [a] NMR per thousand live births

Religion

The majority of mothers (90.6%) were Muslim, and the remainder were Hindus. Hindu mothers lost 3.4% of their newborns, compared to 2.6% of Muslim mothers. The Hindu mothers had a 33% excess neonatal mortality risk compared to Muslim mothers. However, this difference was not statistically significant (OR 1.33; 95% CI: 0.93-1.91: p=0.12) (see Table 6-43).

Maternal education

Maternal education was measured in years of schooling, in four categories: no schooling, 1-5 years (primary), 6-10 years (secondary), and ≥10 years (higher secondary or university education). A little below half of the mothers (44.2%) had completed 6-10 years of schooling, just over one quarter (27.2%) had completed 1-5 years of schooling, and another quarter (24.4%) had never attended school. Only 4.1% had education higher than 10 years.

Maternal education level appeared to be significant predictor for neonatal survival in Matlab. Using the group 6-10 years of education as the reference category, mothers with no schooling were associated with a 32% excess neonatal mortality risk (OR 1.32; 95% CI: 0.99-1.77; p=0.057) and mothers with 1-5 years of schooling with a 30 excess neonatal mortality risk (OR 1.30; 95% CI: 0.98-1.72; p=0.066). Mothers with more than 10 years of schooling had the least risk (34% lower) of losing their newborns, but this did not reach statistical significance (OR 0.66; 95%CI: 0.31-1.42; p=0.288). (see Table 6-43).

Maternal occupation

The great majority of women (86%) identified themselves as housewives who were principally involved in non-paid household work. The other categories of occupation reported included salaried work and small business.

The effect of occupation on neonatal mortality risk was examined using housewives as the reference category. There was no statistically significant difference in the mortality risks between these two categories (OR 0.95; 95% CI: 0.67-1.34; p=0.766). (see Table 6-43).

Mother's parity

Parity is the number of live births a woman has had including the current live birth. Parity was grouped into three categories: one live birth, 2-4 live births, and ≥ 5 live births (grand multiparity). Over half (55.4%) of the mothers had parity ranging from 2-4, while over a third had single parity (35.6%). One in 11 mothers (9.0%) had parity 5 or more.

Considering parity 2-4 as the reference category, mothers with single and multi-parity (≥5) were at increased risk of losing their newborns. Mothers having their first child were associated with a 79% elevated risk (OR 1.79; 95% CI: 1.41-2.29) of neonatal death while women with a parity of 5 or more had a 24% elevated risk (OR 1.24; 95% CI: 0.80-1.91). The excess risk for single parity women was highly significant (p=0.001), while the excess risk for grandmultiparity did not reach significance (p=0.341) (see Table 6-43).

6.4.3 Reproductive covariates

Table 6-44 shows the distribution of singleton births and neonatal deaths in the two-year period (2003 and 2004) across various maternal reproductive characteristics. It also provides the relative risk (odds ratios) of neonates dying across these risk categories. The purpose of this table is to identify areas for maternal intervention in which changes are likely to have an impact in neonatal survival.

Antenatal care during the first trimester

Antenatal care (ANC) was considered to have occurred during the first trimester of pregnancy if a woman had visited a health centre or consulted a medically qualified health care provider (e.g. doctor, nurse, midwife, lady family welfare visitor, medical assistant, other paramedical staff etc) at least once during the first three months of her pregnancy.

About two-thirds (64%) of mothers had not received any ANC during the first trimester of pregnancy. Those mothers who had received ANC had a non-significantly lower risk of neonatal mortality compared to those not receiving ANC (OR 0.87; 95% CI: 0.68-1.11; p=0.261).

ANC use during the last trimester of pregnancy

Antenatal care during the last trimester of pregnancy was considered to have occurred if the woman had visited a health centre or consulted with a medically qualified health care provider (e.g. doctor, nurse, midwife, lady family welfare visitor, medical assistant, other paramedical staff etc) at least once during the last three months of her pregnancy.

Use of antenatal care was higher during last trimester than the first trimester, with over half (53%) of the women receiving such care. These women had fewer neonatal deaths compared to those who had not received any ANC, equivalent to a highly significant reduction (33%) in neonatal mortality risk (OR 0.67; 95% CI: 0.53-0.85; p=0.001).

Place of delivery

Delivery was classified as institutional or health centre (HC) if a woman reported delivery at any health centre, regardless of whether the facility was a primary, secondary or tertiary level centre. The majority of institutional deliveries took place at the Union or sub-district level primary health care centres.

Most mothers (75%) delivered at home. Institutional deliveries were associated with a significantly higher (43%) neonatal mortality risk (OR 1.43; 95% CI: 1.12-1.84; p=0.005) compared to home deliveries.

Service areas

As described in the methodology section, half of the study population (110,000) received maternal and child health services from ICDDR,B while the remainder received standard government health services. Neonatal mortality risk was slightly, but not significantly, lower in women of ICDDR,B area than those from the government service area (OR 0.93; 95% CI: 0.73-1.17; p=0.5).

Table 6-44. Reproductive covariates of singleton live births and neonatal mortality

Reproductive	Singleton live births (N=10844)*		Live births resulting in Neonatal Deaths		Crude			
ANC (1st trimester)	n	*%*	n	*(NMR)*	OR	*(95% CI)*		P
No	6,941	*64.0*	196	(28)	1			
Yes	3,903	*36.0*	96	(25)	0.87	*(0.68*	*1.11)*	0.26
ANC (last trimester)								
No	5,011	*46.2*	163	(33)	1			
Yes	5,833	*53.8*	129	(22)	0.67	*(0.53*	*0.85)*	0.001
Health Centre								
No	8,155	*75.2*	199	(24)	1			
Yes	2,689	*24.8*	93	(35)	1.43	*(1.12*	*1.84)*	<0.01
Service area								
Government	5,408	*49.9*	151	(28)	1			
ICDDR,B	5,436	*50.1*	141	(26)	0.93	*(0.73*	*1.17)*	0.53
Total	10,844		292	(27)				

* Cases where data was complete

6.4.4 Birth characteristics

Table 6-45 shows the distribution of singleton births and neonatal deaths in the two-year period (2003 and 2004) across various birth risk categories of neonates. The purpose of this table is to identify neonatal characteristics that may help in developing appropriate neonatal intervention.

<u>Birth month</u>

As can be seen in Table 6-45, the period November to February was the peak month of delivery (36.9%) closely followed by the July to October period (35%). The risk of neonatal death was the greatest in the March-June period, when it was associated with a 42% elevated risk of dying compared to the reference category period of

November to February (OR 1.42; 95% CI: 1.07-1.88; p=0.015). Births during July to October were not more risky than during the November to February period.

Birth year

There were slightly more births in 2003 compared to 2004 (51.7% vs. 48.3%) of all births. The risk of neonatal death was slightly but not significantly lower in 2004 than in 2003 (OR 0.89; 95% CI: 0.71-1.13; p=0.34).

Sex

There were a similar proportion of males and females born in the study period (51% vs. 49% respectively). Female neonates had a 26% lower risk of dying than males, and this difference was significant (OR 0.74; 95% CI: 0.59-0.94; p=0.013).

Table 6-45. Birth covariates of singleton live births and neonatal mortality

Neonates	**Singleton live births (N=10,844)**		**Live births resulting in neonatal death**		**Crude**			
					OR	***(95% CI)***		**P**
Birth Month	**n**	***%***	**n**	***NMR***				
Nov-Feb	3,997	*(36.9)*	96	*(24)*	1			
Mar-June	3,051	*(28.1)*	103	*(34)*	1.42	*(1.07*	*1.88)*	0.03
July-Oct	3,796	*(35.0)*	93	*(24)*	1.02	*(0.76*	*1.36)*	
Birth year								
2003	5,605	*(51.7)*	159	*(28)*	1			
2004	5,239	*(48.3)*	133	*(25)*	0.89	*(0.71*	*1.13)*	0.34
Sex								
Male	5,529	*(51.0)*	170	*(31)*	1			
Female	5,315	*(49.0)*	122	*(23)*	0.74	*(0.59*	*0.94)*	0.01
Total	10,844		292	*(27)*				

* Cases where data was complete

6.5 Coverage of ANC and Place of Delivery According to Service Area

ANC coverage during the last trimester was much higher in the ICDDR,B area than in the government area (83% versus 24%). Around 40% of mothers delivered at the health centre in the ICDDR,B area, while only 10% did so in the government area, reflecting the national average for facility-based deliveries. ANC and health centre deliveries in the government area are similar to the national average, reflecting home delivery as the norm in the government area and throughout Bangladesh. The distribution of various combinations of ANC type and place of delivery are shown in the Table 6-46 below.

Table 6-46. Coverage of antenatal care (ANC) during last trimester and place of delivery according to service areas

ANC	Place of delivery	ICDDR,B area		Government areas		Both areas	
		N	%	N	%	N	%
No	Home	760	14	3,831	70.8	4,591	42.3
No	HC*	146	2.7	274	5.1	420	3.9
Yes	Home	2,514	46.2	1,050	19.4	3,564	32.9
Yes	HC	2,016	37.1	253	4.7	2,269	20.9
Total		5,436	100	5,408	100	10,844	100

*HC=health centre delivery

6.6 NMR by Service Area According to ANC and Place of Delivery

Within the ICDDR,B area, there were variations in the NMR according to ANC use and place of delivery. Women who did not use ANC during the last trimester experienced a significantly higher NMR than those using ANC, irrespective of the place of delivery. Within the group using ANC, those who delivered at home had a significantly lower NMR than those who delivered at the health centre. Within the group not using ANC, those who delivered at health centre experienced a significantly higher NMR than those delivering at home (see Table 6-47). The implications of these study findings are discussed in greater detail in Chapter 7.
In the government area, the home was the norm for delivery. There were also variations in NMR according to ANC use and place of delivery (see Table 6-47).

Women who did not use ANC during the last trimester experienced virtually a same level of NMR to those using ANC, regardless of the place of delivery. Within the group using ANC, those who delivered at home had a significantly lower NMR than those who delivered at the health centre. Within the group not using ANC, those who delivered at health centre experienced a higher NMR than those delivering at home (see Table 6-47). The implications of these study findings are discussed in detail in Chapter 7.

Table 6-47. Neonatal mortality rate (NMR per thousand live births) by service area according to ANC during last trimester and place of delivery

Service area		**Institutional delivery**	
	ANC	No (Home)	yes
ICDDR,B	No	42.1	109.6
	Yes	15.5	26.8
Government	No	27.1	40.1
	Yes	22.9	47.4

6.7 Interaction Between ANC and Place of Delivery

An interaction between variables means that the effect size of one variable is not the same across all the levels of a second variable. The possibility of an interaction between the place of delivery and ANC was considered. However, the interaction between place of delivery and ANC during last the trimester was not statistically significant for predicting neonatal mortality.

6.8 Unadjusted Odds Ratios With or Without Interaction

Table 6-48 shows the effect on neonatal mortality risk of place of delivery and utilisation of ANC during the third trimester. The effects are observed with interaction between place of delivery and ANC, and also without interaction between these two variables. As can be observed from the table, the analysis produces a number of interesting and important results.

6.9 Effects on Neonatal Mortality Without Interaction

Women who did not use any ANC during the third trimester but delivered at a health centre had an 87% higher risk of neonatal death (OR 1.87; 95% CI: 1.42-2.47) compared to the reference category of women who did not use any ANC and delivered at home. On the other hand, women who used ANC during the third trimester and delivered at a health centre were at the same risk of neonatal mortality as the reference category (OR 1.01; 95% CI: 0.76-1.35). Women who used ANC but delivered at home had a 46% lower risk (OR 0.54; 95% CI: 0.42-0.70) of neonatal death compared to the reference group.

6.10 Effects on Neonatal Mortality With Interaction

The interaction of ANC use and place of delivery acted synergistically to increase the risk of neonatal death, as can be observed in the Table 6-48. With this interaction effect, women who did not use ANC during the last trimester but delivered at a health centre had a 125% increased risk of neonatal death compared to the reference group. This is considerably higher than the 87% increased risk observed without interaction. The odds ratios did not change appreciably with interaction for women of other categories. To sum up, women who did not use ANC during the last trimester but who delivered at a health centre have a greatly increased risk of their infant dying during the neonatal period.

Table 6-48. Unadjusted odds ratios (95%CI) of ANC use during the last trimester and place of delivery on the risk of neonatal death (singletons) with and without interaction

		Institutional delivery	
	ANC	**No**	**Yes**
Without interaction			
	No	1.00	1.87 (1.42-2.47)
	Yes	0.54 (0.42-0.70)	1.01 (0.76-1.35)
With interaction	**ANC**		
	No	1.00	2.25 (1.47-3.44)
	Yes	0.59 (0.44-0.80)	0.98 (0.73-1.32)

6.11 Adjusted Odds Ratios of Covariates for Singleton Births

Logistic regression of singleton births was used to identify predictors of neonatal mortality. All likely predictor variables were included into the model. The 12 covariates were: maternal age, religion, education, occupation, parity, ANC during the first trimester, ANC during the last trimester, place of delivery, service area, birth month, birth year and sex of neonate. The model with all the covariates was considered as the full model.

The overall logistic regression results were tested using Hosmer and Lemeshow's goodness of fit test. The test indicated that the estimates of the full model fit the data at an acceptable level.

Of 11,072 singleton births, 10,844 (97.9%) live births had complete information and were included for analysis. These singleton live births included 292 neonatal deaths giving a neonatal mortality of 27 per 1000 live births. Crude and adjusted odds ratios and their 95% confidence interval (CI) for each of the 12 predictors are shown in three tables 6.9 - 6.11.

6.11.1 Maternal demographic covariates

Table 6-49 shows crude and adjusted odds ratios for each of five demographic predictors in the full model. Among the demographic covariates, only maternal education and parity were significant independent predictors of neonatal mortality ($p<0.001$). Maternal age, religion and occupation were not significant predictors in the adjusted full model.

On adjustment, the odds ratios for all age groups increased except for those below the 20 year group, but none reached statistical significance. Odds ratios were generally slightly raised for education categories except women with more than 10 years of schooling, for whom it dropped from 0.66 to 0.56 compared to the reference category. After adjustment, education categories retained their previous significance level compared to the reference category.

Similarly the odds ratios were higher for women with single parity (1.79 to 2.19), and lower for women with parity five or more (1.24 to 0.87) after adjustment. After adjustment, first births women remained significantly at risk for neonatal mortality while babies born to multiparous women were not at a significant higher risk.

Table 6-49. Crude and adjusted odds ratios of maternal demographic covariates for neonatal mortality (full model)

Demographic	Crude	Adjusted in full model (FM)[a]			
Age	**OR**	**OR**	**(95% CI)**		**P**
<20	1.47	1.13	0.80	1.61	
20-24	1.00	1.00			0.72
25-29	0.90	1.17	0.82	1.67	
30-34	1.03	1.40	0.93	2.12	
35-39	0.90	1.21	0.66	2.22	
≥40	1.11	1.45	0.53	3.96	
Religion					
Muslim	1.00	1.00			0.46
Hindu	1.33	1.15	0.79	1.67	
Education					
None	1.32	1.78	1.27	2.48	
1-5 years	1.30	1.58	1.17	2.12	
6-10 years	1.00	1.00			<0.001
≥10 year	0.66	0.56	0.25	1.24	
Occupation					
House wife	1.00	1.00			0.86
Other	0.95	1.04	0.71	1.52	
Parity					
1	1.79	2.19	1.57	3.05	
2-4	1.00	1.00			<0.001
≥ 5	1.24	0.87	0.52	1.46	

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year and sex of neonate

6.11.2 Maternal reproductive covariates

Table 6-50 shows crude and adjusted odds ratios and their 95% confidence interval (CI) for each of three reproductive predictors from full model variables.

As can be seen in Table 6-10 below, non use of ANC during the last trimester of pregnancy and delivery at the health centre appeared to be independent significant predictors ($p<0.001$) of neonatal mortality. On adjustment, there were no significant changes in these likelihoods. Use of ANC during the first trimester of pregnancy and residence in either service area were not significant predictors of neonatal mortality.

Table 6-50. Crude and adjusted odds ratios of maternal reproductive covariates for neonatal mortality (Full model cont'd)

Reproductive	**Crude**	**Adjusted in full model (FM)[a]**			
	OR	OR	(95%CI)		P
First trimester ANC					
No	1.00	1.00			0.57
Yes	0.87	0.90	0.63	1.29	
Last trimester ANC					
No	1.00	1.00			<.001
Yes	0.67	0.52	0.38	0.72	
Health Centre delivery					
No	1.00	1.00			<.001
Yes	1.43	1.84	1.37	2.47	
Service Area					
Government	1.00	1.00			0.36
ICDDR,B	0.93	1.17	0.83	1.65	

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year and sex of neonate

6.11.3 Birth characteristics

Table 6-51 shows crude and adjusted odds ratios for birth covariates/predictors from the full model variables. The month of birth appeared to be a significant independent predictor for neonatal mortality. Those born during March-June were 42% more likely (p=0.02) to die than the reference category of November-February. There was no noticeable change in this risk after adjustment. Similarly, the sex of the newborn was a significant predictor, with females having a 26% less chance of dying than males (p =0.02). There was no noticeable change in this risk after adjustment in the full model.

Table 6-51 Crude and adjusted odds ratios of birth covariates for neonatal mortality (Full model cont'd)

Neonates	**Crude**	**Adjusted in full model**[a]			
Birth Month	OR	OR	95%CI		p
Nov-Feb	1.00	1.00			
Mar-June	1.42	1.41	1.06	1.88	0.02
July-Oct	1.02	1.01	0.75	1.34	
Birth year					
2003	1.00	1.00			0.34
2004	0.89	0.89	0.70	1.13	
Sex					
Male	1.00	1.00			0.02
Female	0.74	0.75	0.59	0.95	

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year and sex of neonate

6.12 Important Significant Covariates

A backward stepwise elimination method was used to identify significant predictors. The regression model was run after removing unimportant variables one at a time from the full model until all those remaining in the model contributed significantly ($p<.05$). At each step, the variable with the largest p value was removed as long as the p value was greater than 0.05. This model, with significant predictor variables was termed as the constraints model or final model, and generated a Hosmer-Lemeshow χ^2 (8) value of 8.11 and a goodness of fit value of 0.4229. The value of 0.4229 indicates that the final model estimates fit the data at an acceptable level. The likelihood ratio (LR) test was performed between the full and final models with their covariates, and the difference was not significant (LR χ^2 (10)=5.07; p=0.89), indicating that the models were similar.

The odds ratios were slightly raised in the final model compared with the full model odds ratios for covariates of maternal education, ANC, and place of delivery. The odds ratio was slightly reduced for women of single parity women, while they remained almost the same for sex and birth month covariates compared to the reference values.

This suggests that maternal education, first births, ANC during last trimester, place of delivery, birth month, and the sex of neonates were independent predictors for neonatal mortality (see Table 6-52).

Table 6-52. Crude and adjusted OR of selected covariates for predicting neonatal mortality

		Adjusted				
Covariates	**Crude**	**FM**	**CM[a]**	**(95% CI)**		
Education	OR	OR	OR	LCI	UCI	P
None	1.32	1.78	1.91	1.38	2.63	<0.001
1-5 years	1.30	1.58	1.63	1.22	2.19	
6-10 years	1.00	1.00	1.00			
≥ 10 year	0.66	0.56	0.60	0.28	1.31	
Parity						
1	1.79	2.19	2.02	1.56	2.63	<0.001
2-4	1.00	1.00	1.00			
≥ 5	1.24	0.87	0.96	0.62	1.51	
Last trimester ANC						
No	1.00	1.00	1.00			<0.001
Yes	0.67	0.52	0.55	0.42	0.71	
Health Centre delivery						
No	1.00	1.00	1.00			<0.001
Yes	1.43	1.84	1.89	1.42	2.51	
Birth Month						
Mar-June	1.42	1.41	1.41	1.06	1.87	0.03
July-Oct	1.02	1.01	1.01	0.75	1.35	
Nov-Feb	1.00	1.00	1.00			
Sex						0.02
Male	1.00	1.00				
Female	0.74	0.75	0.75	0.59	0.95	

[a]CM stands for constraint model and includes maternal education, parity, ANC during last trimester of pregnancy, place of delivery, birth month and sex of neonate

6.13 Adjusted Relationship Between ANC Use During Last Trimester and Place of Delivery

When the relationship between ANC during last trimester and place of delivery on neonatal mortality was assessed after adjusting for other covariates (maternal education parity, birth month, and sex of neonate), the mothers using no ANC during the third trimester but delivering at a health centre were at greatly increased risk of sustaining a neonatal death. The risk of neonatal death for mothers using no ANC and delivering at home was almost similar to mothers using ANC and delivering at health facilities, while the risk was lower for mothers using ANC but delivering at home. These findings indicate that women who delivered at facilities without using ANC are highly likely to experience complicated deliveries and may have taken too long to reach the facility. Women who used ANC and delivered at health facilities had a similar risk to those delivering at home but with no ANC. This suggests that these at-risk women may have obtained some protection from skilled attendance at a health facility, although this level did not reach statistical significance (see Table 6-53).

Table 6-53. Adjusted odds ratios (95%CI) of ANC use during the last trimester and place of delivery on the risks of neonatal death: without interaction (constraint model/final model)

		Institutional delivery	
	ANC	**No**	**Yes**
Without interaction			
	No	1.00	1.89 (1.42-2.51)
	Yes	0.55 (0.42-0.71)	1.04 (0.77-1.40)

Note: Adjusted for maternal education, parity, birth month and sex of neonate

6.14 Model Statistics

Model statistics test the overall fit of the model with the data. There is no single statistic to assess the overall logistic model. The computer programme Stata generates a pseudo R square value to indicate the degree of variation in the dependent variables explained by the model. The pseudo R square is usually expressed in terms of the Cox & Snell R square or Nagelkerke R square. This value does not reflect the true R square values, and also varies according to the type of pseudo R square. The interpretation of R square is difficult in logistic regression as the predicted and observed outcomes are nominal in type.

Hosmer and Lemeshow's goodness of fit test is a reliable test of logistic model, and is commonly used to judge the fit of data in a model. The test is based on the chi-square distribution. A significance level equal to or more than 0.05 indicates that the model's estimates fit the data at an acceptable level. A receiver operative characteristics (ROC) curve and a likelihood ratio (LR) test are also used to assess the fit between the full and final model.

6.14.1 Model statistic for singleton birth

Table 6-54 shows the model summary of goodness of fit test, the LR test statistic and the area under ROC curve for assessing two models.

In the logistic model, the chi-square value for the Hosmer-Lemeshow test was 3.48 and 8.11 with p values of .90 and 0.42 respectively. Both p values being higher than 0.05 indicated that both the study models fit the data at an acceptable level. The area under the ROC curve and the LR test statistics give an indication about the fit between the full and constraints models (final).

Table 6-54. Statistics of logistic model for predicting neonatal mortality (singleton)

Model Summary	Full model	Final model
Statistics for goodness-of-test		
Number of observations	10844	10844
Number of groups	10	10
Hosmer-Lemeshow χ^2 (8df)	3.48	8.11
p-value	0.90	0.42
Area under ROC curve	0.65	0.65
Test of two models		
Likelihood-ratio test	**Value**	
(Final model nested in full model)		
LR χ^2 (10df)	5.07	
p-value	0.89	

6.15 Analysis of all Live Births

The results of the analysis presented in the subsequent sections are essentially analogous to those presented for singleton births that were described in the earlier sections. A separate analysis was undertaken as the risk of neonatal death with twin and triplet pregnancies is much higher, and the influences on their survival or death may be different. As a proportion of women have contributed more than one birth, and women's health and nutritional status often have influences on birth characteristics too, it is too simple to consider births as if they were independent observation. In this situation, standard logistic regression is not appropriate as it exacerbates the statistical precision with standard errors that are too small and confidence intervals that are too narrow, although point estimates generally remain similar.

In this analysis, women are considered as the primary sampling unit instead of birth and a random-effects logistic regression model is used to identify the point estimate along with confidence interval.

6.16 Crude Relationship Between use of ANC and Place of Delivery

Analysis for interaction was performed for place of delivery and use of ANC during the last trimester to assess their crude relationship in predicting neonatal mortality. The results of this analysis are shown in Table 6-55.

Women who had not used any ANC during the last trimester but delivered at a health centre were 87% more likely to sustain a neonatal death than the reference group of women who had not used any ANC during the last trimester and had delivered at home.

On the other hand, women who had used ANC but delivered at home were 51% less likely to sustain a neonatal death than the reference group.

Women who had received ANC during the last trimester and had delivered at a health centre had a 9% lower risk of sustaining neonatal death than the reference group.

The interaction of ANC use and place of delivery acted synergistically to increase the risks of neonatal death, as can be observed in the table below. With this interaction effect, infant of women who did not use ANC during the last trimester but delivered at a health centre had a 156% increased risk of neonatal death compared to the reference group. This is considerably higher than the 87% increased risk observed without interaction. The odds ratios did not change appreciably with interaction for women with other categories.

Table 6-55. Unadjusted odds ratios (95%CI) of ANC use during the last trimester and place of delivery on the risks of neonatal death (all live births): with and without interaction

		Institutional delivery	
	ANC	**No**	**Yes**
Without interaction	No	1.00	1.87 (1.45-2.42)
	Yes	0.49 (0.38-0.62)	0.91 (0.70-1.19)
With interaction	**ANC**		
	No	1.00	2.56 (1.75-3.73)
	Yes	0.57 (0.43-0.75)	0.80 (0.65-1.14)

6.17 Covariates of Mortality for all Live Births

A random effects binary logistic regression analysis was carried out on live births to assess predictors of neonatal mortality. All predictor variables were included into the model at a time and the model was run. The covariates included: maternal age, religion, education, occupation, parity, ANC use during the first trimester, ANC use during the last trimester, place of delivery, service area, birth month, birth year, sex of newborn, and plurality of birth. The model with all covariates was referred to as the full model.

Of 11,291 live births, 11,055 (98%) had complete records and were included for analysis. These included 352 neonatal deaths giving a neonatal morality rate of 32 per thousand live births. Crude and adjusted odds ratios for each of the 13 predictors were generated from the full model variables, as seen in Table 6-56, Table 6-57, Table 6-58.

Table 6-56. Adjusted odds ratios for maternal demographic covariates of neonatal mortality (all live births) in the full model

	Crude	Adjusted in full model (FM) [a]			
Demographics			**[95% Conf. Interval]**		
Age at birth	**OR**	**OR**	**Lower**	**Upper**	**p**
<20	1.38	1.12	0.80	1.58	0.95
20-24	1.00	1.00			
25-29	0.85	0.99	0.71	1.39	
30-34	0.95	1.05	0.71	1.55	
35-39	1.31	1.22	0.71	2.09	
≥ 40	1.09	1.05	0.40	2.76	
Religion					
Muslim	1.00	1.00			
Hindu	1.22	1.08	0.75	1.55	0.69
Education					
None	1.51	1.94	1.41	2.67	<0.001
1-5years	1.33	1.58	1.19	2.10	
6-10years	1.00	1.00			
□ 10 years	0.56	0.49	0.22	1.09	
Occupation					
House wife	1.00	1.00			0.72
Others	1.07	1.07	0.75	1.53	
Parity					
1	1.41	2.08	1.52	2.85	<0.001
2-4	1.00	1.00			
>=5	1.59	0.96	0.61	1.51	

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year, sex of neonate and plurality of births

Table 6-57. Adjusted odds ratios for maternal reproductive covariates of neonatal mortality (all live births) in the full model

Reproductive covariates	Crude	Adjusted in full model (FM)[a]			
			95% Conf. Interval		
	OR	OR	Lower	Lower	p
ANC (1st trimester)					
No	1.00	1.00			
Yes	0.80	0.87	0.62	1.23	0.44
ANC (Last trimester)					
No	1.00	1.00			
Yes	0.59	0.51	0.38	0.68	<0.001
Health Centre					
No	1.00				<0.001
Yes	1.30	1.61	1.21	2.13	
Service area					
Government	1.00	1.00			
ICDDR,B	0.89	1.24	0.91	1.70	0.18

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year, sex of neonate and plurality of births

Table 6-58. Adjusted odds ratios for newborn birth covariates of neonatal mortality (all live births) in the full model

	Crude	Adjusted in full model (FM[a])			
Birth covariates			**95% Conf. Interval**		
Birth month	**OR**	**OR**	**Lower**	**Lower**	**p**
Mar-June	1.30	1.28	0.98	1.69	0.08
July-Oct	1.05	0.96	0.73	1.26	
Nov-Feb	1.00	1.00			
Birth Year					
2003	1.00	1.00			0.86
2004	0.96	0.98	0.78	1.23	
Sex					
Male	1.00	1.00			0.03
Female	0.83	0.78	0.62	0.97	
Plurality of birth					
Singleton	1.00	1.00			
Multiple births	15.28	19.44	13.37	28.26	<0.001

[a] FM stands for full model and includes all variables: maternal age, religion, education, occupation, parity, ANC during first trimester ANC during last trimester, place of delivery, service area, birth month, birth year, sex of neonate and plurality of births

In the full model, maternal education, parity, use of ANC during the last trimester, place of delivery, sex of newborn, and plurality of birth came out as significant independent predictors of neonatal morality. Strikingly, multiple births carried a 19 times higher risk of mortality than singleton births.

Non-significant covariates included maternal age, religion, occupation, service area, birth month, and birth year. Generally, odds ratios for covariates in the full model were slightly higher except for a few categories (within a variable) where the OR were slightly lower compared to crude OR as can be seen in the tables above.

6.18 Significant Predictors of Mortality

Through backward stepwise elimination method, we removed variables with the highest p values one at time from the full model until all those remaining in the model contribute significantly. These significant variables included maternal education, parity, use of ANC during the last trimester, health centre delivery, sex of newborn, and plurality of births. This model was referred to as the constraint or final model.

Table 6-59 shows important covariates of mortality and the comparison of odds ratios between the full and constraints/final model. In the final or constraint model, maternal education, parity, and use of ANC during the last trimester, health centre delivery, sex of newborn, and plurality of births appeared to be significant independent predictors of neonatal mortality. Multiple births were independently associated with a 19 times higher risk compared to singleton births. On the whole, odds ratios for the covariates in the constraint model were slightly higher or unchanged compared to those in the full model.

Table 6-59. Crude and adjusted odds ratios (OR) of covariates in final model for predicting neonatal mortality (standard logistic regression) in Matlab, Bangladesh

		Adjusted				
	Crude	**FM**	**CM**	**95% Conf. Interval**		**p**
Education	**OR**	**OR**	**OR**	**Lower**	**Upper**	**<0.001**
None	1.51	1.94	2.01	1.48	2.73	
1-5 years	1.33	1.58	1.59	1.20	2.11	
6-10 years	1.00	1.00	1.00			
□10 years	0.56	0.49	0.48	0.22	1.05	
Parity						
1	1.41	2.08	2.13	1.64	2.75	<0.001
2-4	1.00	1.00	1.00			
>=5	1.59	0.96	1.05	0.71	1.54	
ANC (last trimester)						
No	1.00	1.00	1.00			
Yes	0.59	0.51	0.54	0.42	0.69	<0.001
Health Centre						
No	1.00		1.00			
Yes	1.30	1.61	1.66	1.26	2.18	<0.001
Sex						
Male	1.00	1.00	1.00			
Female	0.83	0.78	0.78	0.63	0.98	0.03
Plurality of birth						
Singleton	1.00	1.00	1.00			
Multiple births	15.28	19.44	19.14	13.22	27.72	<0.001

Constraints/final model included education, parity, ANC during last trimester, health centre delivery, sex and plurality of births

6.19 Adjusted Relationship Between Place of Delivery and ANC Last Trimester (final model)

When the analysis was adjusted for other covariates (education, parity, birth plurality, and sex of neonate), the relationships remained essentially similar to those of the unadjusted model, namely mothers using no ANC during the third trimester but delivering at a health centre were at a greatly increased risk of a neonatal death. This held both with interaction and without interaction between ANC use during the last trimester and place of delivery, as can be seen in Table 6-60.

Table 6-60. Adjusted[a] odds ratios (95%CI) of ANC use during the last trimester and place of delivery on the risk of neonatal death with and without interaction

		Institutional delivery	
		No	**Yes**
Without interaction	**ANC**		
	No	1.00	1.64 (1.25-2.16)
	Yes	0.54 (0.43-0.69)	0.89 (0.67-1.19)
With interaction	**ANC**		
	No	1.00	2.10(1.30-2.94)
	Yes	0.61 (0.46-0.81)	0.85 (0.63-1.15)

[a] adjusted for education, parity, sex of newborn, and plurality of births

6.20 Summary of the Chapter

Maternal education, parity, ANC use during last trimester, health centre delivery and sex of newborn appeared to be the significant independent predictors of neonatal mortality both for singleton births and for all live births (singleton and multiple births inclusive). Mothers who did not use ANC during the last trimester but delivered at a health centre were at increased risk of experiencing a neonatal death in both the singleton and all births analysis. Multiple births carried a highly greater risk of neonatal mortality compared to a singleton birth. Antenatal care and quality skilled care at delivery would be expected to have an impact on reducing neonatal mortality in Matlab and similar settings.

CHAPTER 7
Discussion and Recommendations

7.1 Discussion

7.1.1 Introduction

Despite major improvements in under-five survival in developing countries in recent decades, the neonatal mortality rate has remained relatively static (Moss et al. 2002; Lawn, Cousens, and Zupan 2005). The reduction in under-five mortality has been mainly due to interventions that are most effective at the post-neonatal period - immunization, oral rehydration therapy for diarrhoea, management of pneumonia and malaria at the community level, and vitamin A supplementation (Parker 2005). Neonatal deaths now account for greater than two thirds of all deaths in the first year of life, and for about half of all under-five childhood deaths. Further reductions in under-five mortality, especially in South Asia and Africa, which account for the majority of under-five deaths, depend on progress with neonatal interventions (Zupan 2005; WHO 2005; Darmstadt, Lawn, and Costello 2003).

A major constraint to planning neonatal health programmes in developing countries such as Bangladesh is the lack of population level data on causes and differentials of neonatal deaths (Moss et al. 2002). As the great majority of neonatal deaths in these countries occur at home outside the formal health care setting, it is difficult to ascertain the causes, differentials and care seeking patterns with regards to these deaths. In such situations, VA could be a valuable low cost and practical tool to ascertain cause of death (Freeman et al. 2005; Frank et al. 2007; Fauveau 2006).

The research described utilised a VA tool designed to collect data on causes of neonatal deaths in the demographic surveillance area of Matlab in Bangladesh, and to describe differentials and care seeking associated with neonatal deaths. Data analysed were obtained from two sources. First, results from a new VA tool available from 2003 were used to ascertain cause of death and health care seeking information for all neonatal deaths in the surveillance area during 2003 and 2004.

Second, the main demographic surveillance (HDSS) database on all live births and neonatal deaths during 2003 and 2004 was abstracted to examine the effect of maternal demographic, reproductive and newborn's birth characteristics on neonatal survival.

7.1.2 Neonatal Mortality Rate (NMR)

The study found a neonatal mortality rate (NMR) of 32.3 per 1000 live births during the period of 2003 and 2004 in a representative population of 220,000. The NMR was 30.6 in the MCH-FP project area (ICDDR,B area) and 34.1 per thousand live births in the government served area. Both these figures were lower than the national NMR of 41 per 1000 live births (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005) and compare favourably with the global average of 33 per 1000 live births (Lawn, Cousens, and Zupan 2005). However, the NMR in our study was higher than that found in a recent survey from 12 nongovernmental service areas in Bangladesh where the NMR was 19 (range 15-29) per 1000 live births, which was a 50% reduction between 1996 and 2002 in the same area. These areas had a high coverage of reproductive outreach services, although a low rate of skilled/instrumental delivery (Mercer, Uddin et al. 2006; Mercer et al. 2004). The slightly lower NMR in the MCH-FP project area in our study compared to the government area may also have been due to the relatively higher utilization of reproductive outreach services and primary care facilities including basic obstetric care facilities in the former.

7.1.3 Neonatal deaths

<u>Signs and symptoms of fatal neonatal illnesses</u>

Newborns have immature immune systems, making them more susceptible to infections, and can become sick and die very quickly unless they are diagnosed and treated promptly. The symptoms of such potentially fatal illnesses are often non-specific and general such as reduced body movements, and a low or high body temperature (Government of the People's Republic of Bangladesh, WHO, and UNICEF 2001). Timely recognition of danger signs by the mother or care giver is important because failure to understand these signs may delay treatment or referral until the infant is critically ill.

The signs most frequently reported by mothers regarding their deceased newborn were decreased body movements (73.4%), followed by cold body temperature on touch (61%), and cessation of crying (58%). Other commonly reported symptoms and signs included difficult breathing, fast breathing, apnoea, unusual sounding breathing, chest indrawing, unconsciousness, fever, cough, jaundice, and convulsions. Our study findings are consistent with the pool of clinical signs identified by IMCI for classifying young infants at risk of death (Government of the People's Republic of Bangladesh, WHO, and UNICEF 2001). Given the generally low levels of knowledge among parents and caregivers of the importance of such signs, there is a critical need to better utilise antenatal care services and postnatal programmes to raise awareness about these danger signs and appropriate health care seeking. The relatively high rate of utilisation of such services in the ICDDR,B area and areas served by NGOs provides an excellent opportunity to raise such awareness.

7.1.4 Neonatal death according to place of birth and obstetric complications

Obstetric complications during delivery are major risk factors for perinatal mortality in developing countries (Lawn, Cousens, and Zupan 2005; Lawn, Shibuya, and Stein 2005). In a study at Matlab for assessing risk, more than half of the mothers with obstructed labour lost their baby during or shortly after delivery (Kusiako, Ronsmans, and Van der Paal 2000). Other complications associated with very high perinatal mortality were multiple births, eclampsia, breech presentation, prolonged labour, pre-eclampsia and intrapartum haemorrhage. The study found that women without any of above complications had significantly less risk of experiencing a neonatal death.

In this study, limited to neonatal death cases only, there was a disturbingly high rate of reported obstetric complications that are known to be associated with perinatal mortality. The most common of these complications were difficult labour and fever during the last trimester of pregnancy. Over a third of the mothers in our study reported experiencing a difficult labour (36.7%) or fever (36.2%). Other commonly reported complications, all of which predispose to perinatal deaths, included reduced foetal movements during pregnancy, prolonged labour, postpartum bleeding, premature rupture of membranes, jaundice during pregnancy, umbilical cord strangulation, convulsions, and breech presentations.

In this regard, institutional delivery and skilled birth attendance are considered to be key strategies to improve both maternal and newborn survival and well-being. This research found that 64% of deliveries were conducted at home, with the rate being 51% in the ICDDR,B serviced area and 84% in the Government serviced area. Around five of the deliveries required caesarian section, with 9.3% in the ICDDR,B area and 1.6% in the government area. This study also found low level of skilled attendance at delivery, and that institutional deliveries at Matlab were biased towards complicated/referral deliveries.

Given that only 13% of births in Bangladesh are conducted by skilled birth attendants (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005), there is an enormous opportunity to reduce perinatal mortality through increasing the coverage of both institutional delivery and skilled birth attendance (Chowdhury et al. 2007). However, there is a strong need to improve the capacity as well as quality of services in primary care settings for providing emergency obstetric and newborn care. Studies from developing countries have shown that training birth attendants in simple resuscitation techniques can reduce birth asphyxia-related neonatal deaths significantly (PATH 2006; Bang, Bang, Baitule et al. 2005).

7.1.5 Low birth weight

Low birth weight (< 2500g) is a well-documented risk factor for neonatal mortality (Lawn, Cousens, and Zupan 2005). In Bangladesh, LBW prevalence varies between 24% and 41% (Wardlaw 2004; Hosain et al. 2006). Of the neonatal deaths in our study where birth weight was known (n=119), 56% were LBW newborns, indicating the major role of LBW as a risk factor for neonatal deaths in the sample examined. These study findings are similar to global estimates of 40%-80% of neonatal deaths associated with LBW (Lawn, Cousens, and Zupan 2005). An earlier prospective study from Bangladesh found that LBW at least doubled the neonatal mortality and that mortality in such cases tended to occur early (Yasmin et al. 2001).

A number of socio-economic and maternal factors have been found to be associated with LBW. These include the age of the mother, birth spacing, poverty, infections, anemia, multiple-fetal birth, premature birth, lack of antenatal care (Yasmin et al. 2001; Wardlaw 2004; Hosain et al. 2006).

Interventions for preventing low birth weight include both direct and indirect interventions. Indirect interventions include increasing the age of marriage, improving female literacy and schooling, and improving household food security through a range of social and economic measures. Direct interventions include the identification and management of malnourished adolescent girls, and targeted nutritional supplementation for malnourished pregnant women, food supplementation during pregnancy, and management of known risk factors through health education and the health care system. A strategy incorporating both health and non health sectors is necessary for reducing LBW in Bangladesh (Hosain et al. 2006).

However, given the difficulties inherent in preventing LBW, it has been suggested that an emphasis on the care of newborns at high risk of dying may pay greater dividends in the short term (Yasmin et al. 2001). Indeed, two-thirds of all first week deaths can be prevented by simple practices that can improve the survival prospects of LBW newborns such as drying and wrapping the baby after birth, Kangaroo care, early initiation of breastfeeding, and infection management. A community-based study from India used some of the above simple measures to improve the survival of premature and low birth weight babies and showed a significant reduction of neonatal morbidity and mortality (Bang, Baitule et al. 2005). The programme activities at Matlab and other similar settings should include strategies for prevention of LBW as well as ensuring that essential newborn care is available in community and primary care settings. This could produce substantial benefits in the short term.

7.1.6 Multiple births

Although multiple births comprise a small proportion of all live births, it contributes heavily to neonatal mortality (Mercer, Haseen et al. 2006; Katz et al. 2001; Hong 2006). Multiple pregnancies are a major contributor to LBW and increase the risk of neonatal death several fold (Kusiako, Ronsmans, and Van der Paal 2000; Hong 2006). This was observed in this study as well, where multiple births comprised only 1.9% of all live births but contributed to 18% of neonatal deaths. The preceding discussion about low birth weight applies especially to this high risk group of neonates, with their increased incidence of LBW.

7.1.7 Health care seeking prior to death

The described improvements in VA methodology have enabled the collection of data beyond cause of death to additional contextual information on care seeking events prior to death. Since most neonatal deaths occur at home rather than health facilities, the use of VA at the population level provides an opportunity to examine care seeking patterns during the fatal illness episode. Care seeking patterns are locally defined, so an understanding of such practices would be helpful in developing appropriate approaches to reduce neonatal mortality.

This study found medical doctors were consulted most commonly (24%) followed by paramedics (13%) during the fatal neonatal illness episode. The other health care providers involved included kabiraj or herbalists (6.4%), village doctors or unqualified allopaths (using western medicine) (4.1%), and homeopaths (3.5%). Multiple consultations and consultations with qualified medical personnel were more likely in the ICDDR,B compared to the government area, reflecting more utilization of medically-staffed ICDDR,B health facilities.

This reliance on unqualified and or traditional practitioners for ailments has been documented in several studies in Bangladesh. A nationwide study of neonatal illnesses found that most parents sought care from unqualified providers such as homeopath (38%) and village doctors (37%). However, it also reported that mothers who had ANC were more likely to seek care for their newborn’s illnesses from a qualified health care provider (Ahmed et al. 2001). Similarly, the current study shows much less use of unqualified providers at Matlab, where parents were more likely to seek care from health providers trained in the western medicine, in contrast to an earlier period (1989) in Matlab when traditional/unqualified practitioners were more popular (Bhatia 1989). Other studies have confirmed this trend towards seeking care from qualified providers (Mercer, Haseen et al. 2006; Bari et al. 2006).

This study found a disturbingly high proportion of fatal illness episodes that were not treated by any type of practitioners. Although the study did not investigate the reasons for not seeking care, it is unlikely to be different from reasons reported by other studies from Bangladesh. Reasons identified by these studies include the little time that was available to seek care because of the sudden onset of symptoms, the lack of supportive family members, and the cultural restrictions on the mobility of women in public, especially after delivery (Ahmed et al. 2001; Mercer, Haseen et al. 2006). A recent study reported reasons why parents often did not comply with the advice for referral to a hospital given by local health workers/practitioners. These reasons included lack of supportive family members to accompany the mother, bad weather/strikes, the family disliking hospital care, the illness resolving spontaneously, and other reasons including the infant being considered too young to be taken for outside care (Bari et al. 2006).

Seeking the help of spiritual healers (3%) may be linked with superstitious beliefs in some cases. Studies from Matlab as well as from Bangladesh have reported that some mothers believed that evil spirits were responsible for the sickness of their newborn, and that a spiritual healer would be the appropriate person to manage such cases (Fauveau et al. 1991; Mercer, Haseen et al. 2006; Winch et al. 2005).

Although ICDDR,B facilities provide treatment free of cost, utilization of its services is still quite low. The reasons for not seeking care or inappropriate care seeking for neonatal illnesses both at community and facilities level require further research. Public awareness of the danger signs of serious neonatal illnesses, integration of informal practitioners in public health programmes, and improved access to skilled delivery care and essential newborn care would all be worthwhile strategies to reduce neonatal mortality in Matlab and other rural areas in Bangladesh.

A sex differential for seeking care was observed in the present study. Regardless of treatment type, care seeking was greater for males compared with females in the Matlab setting. For nearly half of the female newborns in this study, no care was sought compared to care being sought for 30% of male newborns. Additionally, male newborns were more likely to have received treatment from a medically qualified source (medical doctors and paramedics) than female newborns. Multiple consultations were also higher for male newborns compared to female. This sex bias has been reported from other studies (Ahmed et al. 2001; Bhatia 1989).

Sex bias had been reported not only for health care seeking but also in the allocation of food during mealtimes in an earlier study from Matlab (Chen, Huq, and D'Souza 1981). A recent study from Matlab also reported self-treatment was more common among female patients while medical care on the other hand was more common for males (Ahmed et al. 2003).

Male sex preference also influences the fertility behaviour of people (Rahman and DaVanzo 1993; Unnati Rani and Radheshyam 2007). It has been reported from some parts of India that cultural tradition such as dowry and religious rituals put immense pressure on women to give birth to a male baby. Indeed, in certain states of India the high incidence of selective abortion of female foetuses has resulted in a sex imbalance in the population structure, with males outnumbering females (Oxfam International Briefing Paper 2004). All these findings reflect the poor social status and value traditionally attributed to women and girls in the Indian sub-continent.

The very high proportion of early neonatal deaths in this study that did not receive any outside health care is also of concern. Forty two per cent of early neonatal deaths did not receive any treatment compared to 16% of late neonatal deaths. There could be several reasons for this, as reported by other researchers (Mesko et al. 2003; Winch et al. 2005). Firstly, the cultural tradition of maternal seclusion during the postpartum period is likely to hinder the prompt recognition and treatment of serious neonatal illnesses. This custom has also been reported elsewhere as a reason for delayed health care seeking for newborns. Secondly, the high proportion of neonatal deaths that occur very rapidly (within 24 hours) is another likely reason not seeking care outside home. Thirdly, around 90% of births in Bangladesh occur at home, further limiting access to ready health care when needed. There is an urgent need for immediate postnatal care for high risk newborns (for example those who are premature, have low birth weight, have hypothermia, multiple births). In this regard, skilled attendance at delivery that includes appropriate resuscitation care would be valuable in reducing neonatal mortality.

7.1.8 Causes of neonatal death

The pattern and distribution of causes of neonatal deaths in this study differed somewhat from WHO global estimates, as detailed below.

Birth asphyxia

Birth asphyxia accounted for 45% of neonatal deaths in our study, compared to WHO global estimates of 23-29% (Bryce et al. 2005; Lawn, Cousens, and Zupan 2005). A recent study from Bangladesh which surveyed 12 different geographical areas of the country, also reported a higher proportion of neonatal mortality from birth asphyxia, at 39% (Mercer, Haseen et al. 2006). Another large nationwide survey from South Africa also reported that asphyxia-hypoxia was responsible one-third of neonatal deaths and that intrapartum asphyxia was the primary obstetric cause of deaths from hypoxia (Velaphi and Pattinson 2007).

Several reasons can be postulated for the higher proportion of birth asphyxia-related deaths in Matlab and Bangladesh. First, the high proportion of early neonatal deaths (84%) at Matlab included 38% occurring within the first 24 hours of life. Birth asphyxia is an important cause of early neonatal deaths that is associated with complicated birth, prematurity or severe low birth weight. In particular, low birth weight is associated with a higher incidence of birth asphyxia, as documented in an earlier study in Bangladesh (Yasmin et al. 2001). Also, as mentioned earlier, Bangladesh has one of the highest incidences of low birth weight in the world (Salam et al. 2006). Poor maternal nutrition and health and poverty contribute to low birth weight in the developing countries (Kramer 1987).

Second, in the present study, a high proportion of the neonatal fatalities that had their births at health facilities received intravenous medications for the augmentation of labour. It may be that inappropriate timing and unnecessary use of these medications, such as oxytocics, could have increased the risk of birth asphyxia. A recent study from India reported that the unnecessary use of oxytocics was associated with a three-fold increase (OR 2.6; 95% CI: 1.9-3.6) of birth asphyxia-related deaths (Bang, Bang, Baitule et al. 2005). An earlier study from Bangladesh also indicated that failed or medically induced trial of labour was associated with an increased risk of neonatal death at the health facilities in a rural sub-district of Bangladesh (Bari et al. 2002). Another recent study from South Africa indicated that inadequate foetal monitoring by the health worker was one of the important avoidable factors associated with asphyxia-related deaths (Velaphi and Pattinson 2007).

Finally, an effect due to study artefact cannot be ruled out, as one of the three physicians assigned more than half of the neonatal deaths to birth asphyxia.

<u>Premature birth/low birth weight (LBW)</u>

The proportion of neonatal deaths due to prematurity/LBW in our study, at 15%, is lower than the global estimates of 27% of neonatal deaths occurring due to prematurity. It is also lower than those obtained from recent studies in India (Baqui et al. 2006) and Bangladesh (Mercer, Haseen et al. 2006) where 27% of neonatal deaths were attributed to prematurity/LBW. Several reasons can be attributed for this lower figure in our study. First, the physicians may have had a higher subjective threshold for picking up low birth weight and premature babies as a cause of death. Second, the study physicians used respiratory distress syndrome as an independent cause of death, which is often associated with prematurity, and hence would have left fewer cases to be assigned to LBW/prematurity.

Premature birth is an indirect cause of death while low birth weight is a risk factor for death (Lawn, Cousens, and Zupan 2005). But VA studies have usually not distinguished between these two causes, and have reported them both either singly or in combination as a direct cause of neonatal death. This kind of reporting is a problem for identifying and comparing the magnitude of deaths related to these two factors. Also, neonates within these two categories often have features of respiratory problems and infectious diseases, which make it even more difficult to assign a single cause of death.

Infectious cause of death

Our study found 20.5% of neonatal deaths to be due to infectious diseases (sepsis, meningitis and pneumonia). This is much lower than an earlier study (Chowdhury et al. 2005) of births in 1992-1993 in rural Bangladesh which noted that infectious diseases (sepsis, meningitis, pneumonia and tetanus) accounted for 48.2% of neonatal deaths. However, the lower proportion at Matlab area is consistent with the decline in infectious causes (14.7%) noted as a direct cause of death in the survey of 12 non governmental areas of Bangladesh mentioned earlier (Mercer, Haseen et al. 2006). Also, this study did not find any deaths from tetanus, a condition which would have been more common in 1992-93 when programmes for maternal tetanus prophylaxis had not yet been implemented in earnest, whereas there was almost total coverage with such prophylaxis in the MCH-FP project area at the time of our study (HDSS-Matlab 2007).

Unspecified cause

Physicians in our study failed to assign a cause (unspecified) in 1.4% of deaths, and for another 7.1% cases, the cause was listed as undetermined, as they differed on a cause of death. The unspecified proportion (1.4%) is consistent with the latest nationwide neonatal VA reports, which reported 3.4% of neonatal death as unspecified (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). The nationwide VA survey and our study used a similar modular VA tool in collecting information prior to neonatal death. The use of the new VA tool with a combination of structured questions and open-ended description of symptoms and events yields greater information including on care seeking which helps physicians to allocate a cause for a higher proportion of neonatal deaths. Also, the option to choose a cause of death from an almost unrestricted pool of codes within the ICD-10 classification may have enabled physicians to specify a cause for a greater proportion of neonatal deaths.

Interestingly, on comparing with data from the Matlab HDSS prior to 2003 (personal communication), it was found that the old, pre-2003 VA tool diagnosed 16.6% of neonatal deaths as being due to unspecified causes, compared to the 1.4% in our study. This indicates that our VA tool was much more effective in assigning a specific cause of death.

Cause of death across studies

Community-based studies in South Asia, mainly from Bangladesh, India, Pakistan and Nepal have reported neonatal cause of death within the following ranges: birth asphyxia (8-39%, sometimes including birth injury), sepsis or pneumonia (7-52%), prematurity (8-38%), neonatal tetanus (1-36%) and diarrhoea (9%) (Bang and Bang 1992; Bang, Paul et al. 2005; Bang, Reddy et al. 2005; Baqui et al. 2006; Baqui et al. 2001; Bhatia 1989; Chowdhury et al. 2005; Fauveau et al. 1991; Fikree, Azam, and Berendes 2002; Freeman et al. 2005; Mercer, Haseen et al. 2006; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005; Shrivastava, Kumar, and Kumar Ojha 2001).

It was revealed on reviewing the above studies that they often used different criteria and methods to allocate cause of death. These methodological differences between studies as well as in the levels of neonatal mortality make direct comparison difficult. For example, some studies used different definitions and grouping of causes that overlapped those used in our study, or excluded causes that have been included in our study. These differences can result in the distortion of proportions in certain categories. For example, the absence of one category such as prematurity in some studies almost certainly results in some neonatal deaths being classified as tetanus.

These methodological differences explained some of the differences noted in the distribution of causes of deaths in our study. The identification and implementation of a common VA methodology, which includes: a standard VA tool with a core set of questions, a standard method for interpreting cause of death and a standard set of categories of cause is a research priority. The standardised methodology would enable both researchers and programme managers to compare and assess cause of death over time and across study sites within and between countries (Frank et al. 2007; Setel, Rao et al. 2006; Soleman, Chandramohan, and Shibuya 2006).

7.1.9 Differentials of cause of death

Cause of death by early and late neonatal period

The current study findings suggest that non infectious causes (birth asphyxia, prematurity/low birth weight) are common in the early neonatal period, while infectious causes (sepsis/meningitis and pneumonia) are the major causes of late neonatal deaths at Matlab. These results are consistent with community-based neonatal mortality studies from developing countries (Lawn, Cousens, and Zupan 2005).

Recent global estimates for the proportion of neonatal deaths occurring on the day of birth have ranged from 25 to 45% (Lawn, Cousens, and Zupan 2005). These study findings are similar to our study and other recent studies conducted in Bangladesh (Mercer, Haseen et al. 2006; National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). Birth asphyxia and prematurity/low birth weight are major causes of early neonatal deaths in poor, developing countries, highlighting the need for resuscitation care for birth asphyxia and appropriate management of premature and low birth weight babies.

Cause of death by sex

Morbidity and mortality are consistently reported to be higher in males than in females in early life (WELLS 2000; Xu et al. 1997). In our study too, males accounted for a larger proportion of all deaths (55%). Birth asphyxia was the most common cause of death for both males and females, even though the proportions differed significantly (males 51% versus females 38%). Prematurity/low birth weight and pneumonia were more likely causes of death among males while meningitis/sepsis, RDS, and other causes were major contributors to deaths among females. Overall, these differences were significant ($p<0.05$). While it has been reported that males are more vulnerable to environmental stress in early life, (WELLS 2000), the explanation of these differentials in cause of death between the sexes observed in this study goes beyond the scope of the study.

Cause of death by service area

The major cause-specific mortality fractions between two service areas were very similar during the study period except in the case of prematurity/low birth weight which was much more common in the ICDDR,B area than the government service area. Prematurity/low birth weight comprised 21% of neonatal deaths in the

ICDDR,B area compared to 10% in the government service area ($p<0.05$). This significant difference in Matlab needs to be investigated further.

7.1.10 Interventions to reduce perinatal deaths

As most neonatal deaths occur during the early neonatal period, a perinatal death audit could help in identifying avoidable factors for reducing neonatal mortality, as was found in Nepal and Sri Lanka where such audits were used to design successful strategies for reducing perinatal and neonatal deaths (Shrestha et al. 2006; Lucas and Ediriweera 1996). Medical audit is a widely promoted strategy for improving quality of care in hospital and to promote change in maternal and perinatal death (Mancey-Jones and Brugha 1997). A recent study from rural Uttar Pradesh, India found that community neonatal death audit was an acceptable participatory approach for identifying avoidable factors associated with death and discussing solutions (Patel et al. 2007).

Such audits can also help identify barriers in the health care seeking pathway that contribute to preventable deaths. For example, a recent study in South Australia used perinatal death audit in identifying barriers relating to access to care, factors relating to delayed presentation to medical care, and factors relating to deficiencies in professional care (de Lange et al. 2008).

A recent survey from Matlab documented that failure to understand the seriousness of health problems, the cost of medical care, and difficulties with transport were common reasons for delay in seeking health care. Particularly for delivery-related complications, organization of transport and the time required to reach health facilities were inordinately long (Killewo et al. 2006). Another barrier to institutional deliveries in Bangladesh is the socio-cultural norm which favours birth at home (Parkhurst, Rahman, and Ssengooba 2006). Past studies from Bangladesh have described several reasons for cultural or social norms for home delivery. For example, the vast majority of people in rural Bangladesh believe that child birth is an act of Allah and a natural event/process, or even consider it a test for women to endure the pains of childbirth on their own. An anthropological investigation identified that blame was attributed to women who needed delivery assistance in a health facility, some that misdeeds by these women are considered to have invited obstetric complications. Other common socio-cultural barriers for institutional delivery include female privacy, embarrassment at physical examination, fear that hospital deliveries can be harmful, the low quality of services at hospital, and unfriendly staff (Afsana and Rashid 2001; Gazi, Goodburn, and Chowdhury 1999; Parkhurst, Rahman, and Ssengooba 2006; Paul and Rumsey 2002). These identified cultural and socio-economic barriers are important considerations for developing of appropriate interventions to further improve neonatal survival in developing countries.

There is a wide range of evidence-based activities that can reduce neonatal mortality in the community. These include health education, behaviour change communication about safe motherhood, community awareness, pre-planning about delivery, family/home care, good outreach services, continuity of care, skilled attendance at delivery, training of staff in early resuscitation techniques, and community-based management of neonatal health problems backed by facility-based essential neonatal care unit (Arifeen, Black, Antelman et al. 2001; Bang, Bang, Baitule et al. 2005; Bhutta et al. 2005; Knippenberg et al. 2005; Parkhurst, Rahman, and Ssengooba 2006; Syed et al. 2006).

Targeted health education alone can bring about significant beneficial changes to health care and care seeking by family members. Such education could be on clean delivery practices, immunization, and breastfeeding immediately after birth and prompt care seeking for complications. This was observed in a recent evaluation from Bangladesh where trained community health workers made door-to-door visits to raise awareness among pregnant women of newborn care practices (Syed et al. 2006). These visits were effective in significantly improving neonatal care practices such as drying and wrapping of baby immediately after birth, initiation of breastfeeding within one hour of birth, and early postnatal newborn checkups. Mothers' knowledge of postnatal danger signs had also increased significantly.

Recent studies both from community and hospital suggest that improved care of preterm care or LBW infant can improve neonatal survival substantially (Bhutta et al. 2005; Darmstadt, Bhutta et al. 2005). Promotion of early and exclusive breastfeeding (Bhutta et al. 2005; WHO Collaborative Study Team 2000), hypothermia prevention and treatment, including kangaroo mother care (Christensson et al. 1998; Conde-Agudelo, Diaz-Rossello, and Belizan 2003;

Quasem et al. 2003; Darmstadt, Kumar et al. 2006), topical skin cleansing with chlorhexidine (McClure et al. 2007), and topical emollient (sunflower oil) treatment for hospitalized infants (Darmstadt, Saha et al. 2005) could reduce morbidity and mortality in LBW and premature birth infants. A recent community-based study from India (Bang, Baitule et al. 2005) also found that home-based management of LBW and preterm neonates is feasible and effective in improving newborn survival.

Although infectious causes (sepsis/meningitis and pneumonia) were the major contributor to late neonatal deaths in our study, they are important in early neonatal deaths too. Most early infections are usually acquired from the mother, and thus management of maternal reproductive and urinary tract infections can prevent transmission of these infections to newborns. In addition, community-based studies from developing countries have reported that clean delivery practices such as hand washing, cleaning birth passages with chlorhexidine, clean cord cutting, and applying chlorhexidine over the cord can reduce neonatal infections and infection-related mortality. Late neonatal deaths due to neonatal tetanus can be successfully prevented by tetanus toxoid immunization in the pregnant mother as well as through clean cord care (Bhutta et al. 2005; Darmstadt, Kumar et al. 2006; Darmstadt, Nawshad Uddin Ahmed et al. 2005; McClure et al. 2007).

Although WHO advocates that very severe neonatal illnesses including sepsis (Government of the People's Republic of Bangladesh, WHO, and UNICEF 2001) be treated in a hospital, studies in India have shown that community-based management of sepsis using trained village health workers can be effective in reducing neonatal mortality (Bang et al. 1999; Bang, Bang, Stoll et al. 2005; Sazawal and Black 2003).

In summary, for Matlab or similar settings, targeted neonatal interventions for birth asphyxia, prematurity, low birth weight, and infections are the key to substantially reducing neonatal mortality.

7.1.11 Comparison of methods for assigning causes of death

As most neonatal deaths in developing countries occur outside the health care system, VA is increasingly being used because of its low cost and ease of use in collecting data. However, there are some methodological issues with allocating cause of death from the information obtained through VA. Usually, physician review and algorithms have been used after validating them using hospital diagnosis as the gold standard. But the reliability and validity of cause of death are dependent on the quality of information obtained and the accuracy of the "gold standard" diagnoses. Hospital diagnosis, usually used as the reference or gold standard diagnosis, is often not representative of community morbidity. In resource-poor health care settings, hospital diagnoses are often unavailable, and even when available are limited by inadequate clinical data and record keeping.

Although physician reviews have their limitations, they have been commonly used to allocate cause of death by reviewing and interpreting VA information. Given that physician time is costly and often not available in rural areas, this study compared the agreement and cause-specific mortality fraction (CSMF) of medical assistant review, and algorithm-based assignment with physician review. The diagnostic accuracy of medical assistant and algorithm method were assessed separately using physician agreed cause of death as the reference diagnosis.

Comparison of physicians' review, medical assistant review and algorithm approach for determining major causes of death showed that the three approaches were reasonably consistent in assessing the cause-specific mortality fraction (CSMF) of the major neonatal causes of death in this Matlab community setting. Patterns of major causes obtained were also similar to with those reported from other community-based studies in South Asian countries. Five major categories of neonatal deaths accounted for more than 80% of all neonatal deaths, as determined by the two out of three physician agreement "reference method", medical assistant and algorithm approach. However, there was some variation with regards to the rank of individual causes within the five major categories of causes. These causes were birth asphyxia, prematurity/low birth weight, respiratory distress syndrome, pneumonia and sepsis/meningitis.

The algorithm assigned a number of rare causes such as neonatal tetanus and diarrhoea, and this may have been due to misclassification errors (Anker 1997). Neither, reference method review (at least two physicians agreeing on the cause) nor medical assistant review assigned any deaths to tetanus. In this respect, the physician and medical assistant reviews can be assumed to be more accurate due to their local knowledge and use of their clinical judgement. In this study setting, coverage of tetanus toxoid immunization is almost universal. Similarly, diarrhoea is another category of cause of death assigned by algorithm, but the medic's review did not assign any such a category as a cause of death. Diarrhoea is a rare illness among neonates in the Bangladeshi setting. So, it is quite likely that the algorithm-based assignment of diarrhoea was a misclassification error.

The VA puts emphasis on causes of death which have major public health importance (Fantahun et al. 2006). This public health or community approach has been reflected here by all three VA approaches which show the same common patterns of causes of neonatal death as those reported previously from the developing countries. Therefore, it seems fair to propose that medical assistant and algorithm methods could be used in combination for allocating major causes of public health importance where physician time is scare.

Our study found a good level of agreement, when assigning birth asphyxia as a cause of death, between physician review and medical assistant (kappa value=0.77) and between physician and algorithm (kappa=0.69). A kappa value of 0.80 indicates almost perfect agreement between two methods. The corresponding agreement for sepsis/meningitis was moderate between physician and medical assistant (k=0.53) but was poor between physician and the algorithm (k=0.23). Agreement were moderate for prematurity/low birth weight (k=0.55), RDS (k=0.59), pneumonia (k=0.51) and meningitis/sepsis (k=0.53) between physicians and medical assistant.

There are no published data comparing physician review with review by medical assistant. However, there is one study (Freeman et al. 2005) from Nepal comparing physician and algorithm-based diagnoses which found rather poor agreement for birth asphyxia and sepsis. One reason for this difference with our study could be the greater familiarity of the study physicians and the medical assistant with the possible early and late neonatal causes of death through their knowledge of the manual and the guidelines of Integrated Childhood Management Illness. Such knowledge could have enabled the medics in this study to assign birth asphyxia to those cases of neonatal deaths that were characterised by lack of normal crying after birth, whereas in the Nepalese study the physicians may have been more likely to apportion such cases to the category of unspecified causes. Also, the current study used hierarchical algorithms with a predefined order of application which assigned a single cause of death for each case, while the Nepalese study allowed for multiple causes to be assigned for any death.

The medical assistant in our study had a moderate to good agreement with study physician1 and study physician2 for all major categories of death, while for study physician3 this agreement was good for birth asphyxia and fair to moderate for the other causes. Thus, overall, the performance of the medical assistant was consistent with the study physicians. However, for the hierarchical algorithm-based method in our study, it compared well with all three physicians only for birth asphyxia, while it was moderate to poor for the other causes.

Overall, the medical assistant-based diagnoses performed marginally better than the algorithm-based method in our study. The observed sensitivities and specificities across the five major cause of death varied from 48%-84% and 93%-98% respectively for medical assistant against physicians (reference method). The corresponding sensitivities and specificities between algorithm-based causes and physician causes were 39%-77% and 87%-96% respectively.

In conclusion, a well-trained medical assistant and a hierarchical algorithm could reduce dependence on physician input to provide accurate assignment of neonatal causes of death from VA data where physician time is scare. A medical assistant is less costly than a doctor and they usually remain in the rural area. The automated hierarchical algorithm is less labour intensive, since at an estimate of 10 minutes per physician for VA interpretation, even a small study such as this required more than three weeks of physician time for VA interpretation. Also, the algorithm can be applied to a large number of VA interviews quickly without any inter-observer variation.

Further validation research using medically-confirmed gold standard diagnosis and triangulation of methods is needed at Matlab to refine the methods for determining causes of death and their reliability. Research is also needed for validating VA methodology techniques (core questionnaires, guidelines for its use, and common & reliable method for interpreting cause of death) in different countries/setting with different patterns of mortality in order to compare results across settings within and between countries. A most effective way of utilizing the medical assistant's review and the automated algorithm methods together is important for improving cause of death determination by VA methodology.

7.1.12 Predictors of neonatal mortality among singleton births

Antenatal care (ANC)

Findings from the analysis indicate that women who received antenatal care during the last trimester had a lower risk of death for their newborns during the first four weeks of life, broadly reflecting findings from other studies (Feresu et al. 2005; Hong and Ruiz-Beltran 2007; Humphrey and Keating 2004). While neonatal mortality rate is still high at Matlab, infants of mothers who received antenatal care during last trimester were 33% (unadjusted OR 0.67; 95% CI: 0.53-0.85) less likely to die during the neonatal period than those whose mothers did not receive antenatal care.

This protective effect of antenatal care on neonatal survival persisted (adjusted OR 0.52; 95% CI: 0.38-0.72) after adjusting for factors such as maternal age, education, parity, religion, occupation, service area, place of delivery, sex, birth year and birth months. This finding is consistent with results from other studies (Cruz-Anguiano et al. 2004; Eshleman, Poole, and Davidhizar 2005; Hong and Ruiz-Beltran 2007) and provides further evidence that antenatal care during the last trimester is an important determinant of child survival in developing countries.

Association of ANC and place of delivery with mortality

ANC use was significantly associated with a lower risk of neonatal mortality regardless of the place of delivery. ANC provides an opportunity for counselling for safer motherhood and preparedness, and links women with the formal health services. There are mixed experiences with regard to the effect of institutional deliveries on pregnancy outcomes, as these centres usually deal with complicated deliveries, and often women delay presenting to health centres for deliveries due to various factors including cultural norms of the geographical area (Parkhurst, Rahman, and Ssengooba 2006).

Although health centre deliveries were associated with a higher risk of neonatal mortality in our study, not receiving any ANC was associated with an even higher risk of neonatal mortality among health centre deliveries. This was particularly obvious in the ICDDR,B area for those women who did not use ANC but delivered at a health centre, indicating that this group of women may have been somewhat different from other women in the ICDDR,B area. Women who are not accessing antenatal care regardless of place of delivery tend to come from a higher risk category. Understanding their reasons for not accessing antenatal care during the last trimester would be helpful in designing culturally acceptable care options for this high risk group of women. Although not statistically significant, there was a substantial reduction of NMR in the ICDDR,B area for women who had both received ANC and delivered at a health centre compared to those in the government area, indicating the potential for reduction of NMR with antenatal care and skilled attendance at delivery.

Although the interaction between ANC and place of delivery was not statistically significant, it acted synergistically to substantially increase the risk for those women who did not receive ANC but delivered at a health centre. There was no appreciable change for other combinations of ANC and place of delivery.

Although this study did not collect data on reasons why this group of women delivering at a health facility did not receive antenatal care, it can be assumed that these women initially proposed to have a home delivery, but were compelled to attend a health facility when their childbirth became complicated. Several reasons could be postulated for this group of women. The problem may be either at the community level – physical, social, or financial factors limited them in accessing maternity care in time, or the problem is along the referral chain between health facilities or between community and health facility. This kind of delay which contributes to complications is known as the second delay. Home is the cultural norm for delivery in Bangladesh so that many women and families only attend a health facility when labour gets complicated. Another possibility of delay in accessing a health facility is the delay by women and families in recognising the need to seek care at health facility, known as first delay (Thaddeus and Maine 1994).

Socio-economic and demographic correlates are important for identifying target groups for intervention, but they neither explain delivery behaviour nor do they suggest locally/culturally appropriate intervention measures (Amooti-Kaguna and Nuwaha 2000). Both formative and explorative research are needed to better understand the delivery behaviours and factors affecting choice of delivery and the appropriate intervention measures for enhancing the uptake of institutional deliveries.

In the current study, institutional deliveries were associated with a higher risk of neonatal mortality. Although the study did not have data on complications during delivery, institutional deliveries in Bangladesh generally tend to be complicated deliveries. Analysis of the cases delivered at health facilities where the newborn died provides a couple of insights: women with very serious complications either arrive too late to benefit from medical care or they fail to receive timely and effective treatment. The latter explanation is related to the quality of care in health facilities. In a recent review by the Lancet Maternal Survival Series Steering group, Koblinsky and colleagues (Koblinsky et al. 2006) pointed out that maternity care services in many developing countries are often substandard; the facilities often lacking skilled providers and the necessary logistics to deliver services. These factors are also described as the major obstacles for the expansion of institutional delivery in developing countries. Inadequate knowledge and skills of providers, lack of adherence to good clinical practice, lack of adequate supplies and logistics, inappropriate management of complications and untimely care for life-threatening complications, deliveries unattended or with unskilled/unqualified attendants even at facilities, unfriendly behaviour of staff, and a lack of continuity of care are contributors to substandard care in many health facilities within developing counties (Koblinsky et al. 2006; Ronsmans and Graham 2006).

The higher risk of neonatal mortality in institutional deliveries in Bangladesh can signify one or both of the following: firstly, that these deliveries represent the severe end of morbidity spectrum, or secondly, that skills, resources and service quality at the institutional level are inadequate to treat such complicated cases (Bari et al. 2002; Hong 2006; Hong and Ruiz-Beltran 2007). As noted earlier, obstetric complications such as eclampsia, breech, prolonged labour, multiple pregnancy, and intrapartum haemorrhage are associated with increased perinatal mortality risk, and are also more likely to lead to hospitalised delivery (Kusiako, Ronsmans, and Van der Paal 2000).

Although the level and organization of hospital services can be important factors in patient survival, researchers in a hospital-based analysis in the Thames region in the UK did not find any association between hospital-related factors and the neonatal mortality rate. However, they did find a significant impact on reducing the stillbirth rate, especially for those hospitals that applied interventional approaches and had a higher proportion of obstetricians (Joyce, Webb, and Peacock 2004). A recent study from India found that inappropriate use of oxytocics for deliveries by untrained providers increased the risk of neonatal mortality (Bang, Bang, Baitule et al. 2005).

However, there are encouraging results from community-based studies from developing countries regarding the training of birth attendants and effects on perinatal and neonatal mortality. In a meta-analysis, Sibley and Sippe found that training of traditional birth attendants was associated with reduced perinatal mortality and death from birth asphyxia (Sibley and Ann Sipe 2004). A recent study from Bangladesh also found a low neonatal mortality rate in 12 non-government service areas in different parts of Bangladesh where the majority of deliveries in the areas were attended by trained birth attendants (Mercer et al. 2004; Mercer, Uddin et al. 2006). Mercer and colleagues (Mercer, Haseen et al. 2006) carried out a subgroup analysis and compared women who delivered at home with complications and without complications. Women with complications who delivered at home were 2-3 times at increased risk of losing their newborn compared with women without complications. Although the small sample size limited the generalization of these findings, it provides further evidence that institutional deliveries are generally biased toward mothers referred due to complications.

Regardless of mechanism by which neonatal mortality was linked to ANC and institutional delivery in the current study, two facts stand out. One, neonatal mortality was lower in the ICDDR,B area compared to the government area. Two, maternal mortality was also lower in the ICDDR,B area compared to government area. The latter observation was recently demonstrated from the same Matlab area in a cohort study (Chowdhury et al. 2007; Hurt et al. 2008). This study, which followed surveillance data from the Matlab HDSS from 1976 to 2005, found that maternal mortality fell by 68% in the ICDDR,B area compared to 54% in the government area. This better maternal survival in ICDDR,B area could be attributed to a fall in abortion-related deaths and better access to emergency obstetric care (EmOC). Skilled care during delivery has been linked to greater neonatal survival (Hurt et al. 2008; Lawn, Cousens, and Zupan 2005). Thus it is likely that the better maternal and child care in the ICDDR,B area in the form of ANC, skilled-birth-attendant and access to EMOC would have contributed to the lower neonatal mortality observed in the area. Investments in midwives/skilled-birth-attendant and EMOC have clearly important in improving maternal and neonatal survival.

However, more attention to activities such as monitoring staff preparedness, facility preparedness, and community engagement in maternity care and neonatal care are necessary to further improve the maternal and neonatal survival. Confidential enquiries and clinical audits of maternity services, neonatal deaths and newborn care can be carried out to improve and sustain the quality of care at health facilities in developing countries.

7.1.13 Effect of other factors on neonatal mortality

A number of other factors were also identified, after adjustment, as significantly associated with increased neonatal mortality risk. These included maternal education, parity, sex of newborn, and birth month and are discussed in greater detail below.

Consistent with previous studies, this study found maternal education to be a key factor in promoting child survival (Defo 1996; Pena, Wall, and Persson 2000; Hossain, Phillips, and Pence 2007). Maternal education was significantly and positively associated with neonatal survival, and this effect persisted and became larger after adjustment. Educated mothers not only have better health-seeking behaviours, but also possess better coping skills when faced with harsh living conditions in which children are more susceptible to death. Educated mothers are also more prepared to demand care or assistance from society if needed. Although maternal education is a long term strategy, promotion of maternal education is likely to have a significant impact on reducing socio-economic differences in neonatal mortality in Matlab and similar settings in developing countries.

There is a U-shaped relationship between neonatal mortality and child birth order. In our study, first order children, as well as those born fifth order and above, were at greater risk of death during the neonatal period compared to children born second to fourth order. This phenomenon has also been noted in other studies from developing countries (Hong and Ruiz-Beltran 2007; Pena, Wall, and Persson 2000).

Our study found that female neonates had a significantly lower risk of dying than male ones. This difference, which is universally acknowledged, is due to the biological advantage enjoyed by female infants and the increased vulnerability of male children in their early years to environmental stress (Hong and Ruiz-Beltran 2007; Mohsin, Bauman, and Jalaludin 2006; WELLS 2000).

Births and deaths have striking seasonal patterns in Bangladesh. Like previous studies, our study also found a higher proportion of births (37%) occurred during the period November-February. However, contrary to earlier studies which reported a peak in neonatal deaths in November (winter time) (Bahl et al. 2005; Becker 1981; Becker and Weng 1998; Kynast-Wolf et al. 2006), the current study found the peak period for neonatal deaths to be during the months of March to June (summer period). It would be helpful to explore this difference in seasonality further, as there may be a complex interplay of reasons relating to foods, food availability, and other as yet undefined socio-economic aspects.

7.1.14 Predictors of mortality among all live births

A multivariate logistic analysis with the mother as the unit of analysis was conducted on all live births including multiple and singleton births. Maternal education, parity, antenatal care during the last trimester, and the sex of the newborn were independently and significantly associated with neonatal death. Strikingly, multiple births carried a 19 times higher risk of mortality than singleton births.

Multiple births are often associated with higher perinatal and infant mortality rates due to the higher risk of complications during pregnancy and delivery, greater probability of low birth weight babies, premature delivery and higher risk of infection. This is compounded in Matlab by the lack of access to appropriate access to appropriate obstetric care.

The unadjusted analysis showed that multiple births had more than a 15 times higher likelihood of mortality during the neonatal period compared to singleton births. When adjusted for other explanatory variables (maternal age, religion, occupation, and parity, ANC during first and last trimester, birth month, birth year, sex, and service area), this association was further strengthened. These findings are consistent with findings from both developing and developed countries (Hong 2006; Mohsin, Bauman, and Jalaludin 2006) and confirm that high risk pregnancies contribute to higher levels of infant mortality.

The strong relationship between multiple births and neonatal mortality indicates the need for accessible screening and referral services for multiple pregnancies at the community level. There has been a notable 20% increase in antenatal care coverage in developing countries since the 1990s, and currently just over 70% of women worldwide receive antenatal care at least once from a qualified skilled provider as of 2001 (WHO 2003, 2005). However, coverage is still low in South Asian countries, where only 54% of women receive antenatal care. For example, in Bangladesh almost half of all the pregnant women do not get any antenatal care (National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro 2005). An earlier study from Bangladesh showed that antenatal screening could effectively identify women with twin pregnancies for institutional deliveries (Vanneste et al. 2000). Screening for twin pregnancies through increasing the coverage of antenatal care at the community level with referral networks for institutional delivery could prevent a significant proportion of neonatal death.

Poverty is linked to maternal and neonatal mortality (Lawn, Cousens, and Zupan 2005; Ronsmans and Graham 2006). It affects neonatal survival either through increasing prevalence of risk factors or limiting access to effective care. Chowdhury and colleagues have shown the use-inequality both for home and facility-based maternity care exists in Matlab where both services are free of charge (Chowdhury et al. 2006). Another recent study from Bangladesh also reported the substantial use-inequities for maternal health-care services even with home-based skilled-birth-attendant programmes (Anwar et al. 2008). Researchers already have started expressing concerns that MDG-4 and MDG-5 could not be achieved without further improvement in coverage among poor people (Razzaque, Streatfield, and Gwatkin 2007).

In summary, it is important to identify women at risk so that appropriate care options can be provided to them to reduce neonatal mortality further at Matlab. Strategies to improve neonatal health should include antenatal care, introduction of perinatal death audits, ensuring a higher level of skilled birth care at delivery with emphasis on appropriate resuscitation measures for newborns, and better overall care for neonates. Among other factors, management of pregnancy-related complications and arrangements for averting low birth weight through adequate nutrition for pregnant women are important. Long-term strategies such as women education and poverty reduction are essential to sustain the achievements and to improve neonatal survival further. Means of addressing inequity should be an integral part of all strategies/programmes for improving survival of newborn babies.

7.1.15 Study strengths

This study had the advantage of being population-based, having a large sample size and a short recall period for data collection. The population level data were collected through a highly intensive and rigorously audited demographic surveillance system that captured all births and deaths by reliable female community health research workers carrying out monthly household visits, a system well accepted by the local people. A standardised modular VA tool was used to collect the detailed information on all neonatal death cases including care seeking. Causes of death were assigned by three different methods independently interpreting same VA interviews.

7.1.16 Study limitations

Absence of a medically-confirmed gold standard diagnosis for comparing cause of death is a major limitation of the study. The emphasis on using only single causes of death may have also obscured multiple causes contributing to neonatal death. The symptom-based assessment of causes used in this study was highly culture-specific, and required a considerable degree of preliminary preparatory work on local perceptions of health and disease. This study collected information on source of care seeking but did not collect much detail on care seeking that limited the conclusions on the circumstances and barriers to care seeking in the study.

The study also has the usual drawbacks common in observational studies. Information on certain important confounders could not be collected, and this could have biased the associations detected. For example, the greater association between institutional delivery and neonatal mortality could also have been due to the higher proportion of complicated labour cases that took place at a facility rather than at home. This study reports place of delivery, but did not collect information about the circumstances that preceded to delivery limiting the conclusion that more complicated deliveries ended up giving birth in health centre. Other known risk factors for neonatal mortality were not collected such as past obstetric factors, maternal anthropometric measures, maternal illnesses/complications during pregnancy and delivery, the birth weight and gestational age of the newborn and socio-economic status, all of which may have influenced the associations detected in the study.

7.2 Conclusion, Recommendations and Future Research

The study findings from the rural Matlab, Bangladesh have several implications regarding VA methodology and for programmes directed at improving neonatal and child survival in low-resource settings in developing countries.

Firstly, medical personnel (physicians and medical assistant) were able to specify a primary (direct) cause of death for almost all neonatal deaths; this may have been possible because of the greater amount of information collected through the newly introduced VA tool and the option of choosing a possible cause from an almost unlimited pool of causes within ICD codes. In this regard, they did not explicitly use or refer to specific categories of causes such as those used to present the causes for the purpose of this dissertation. However, using such categories to help them specify a cause of death may be more useful for comparison with other countries and following the trend of causes of neonatal death in Matlab. Research is also needed to understand the causes of stillbirth, an important cause of loss of life and DALY burden.

Secondly, in the absence of a gold standard, major causes of neonatal death could be determined equally well by both physicians and by the medical assistant from the VA interview data. A well-trained medical assistant can reduce the need for physician input to classify major causes of neonatal death in settings where physicians are scare. Algorithms can also reduce requirement for physician inputs in major categories of death, specially birth asphyxia and pneumonia if definitions for causes and the hierarchical structure can be maintained. However, while the algorithm method removes human bias, it can not adequately account for local factors and overestimated rare causes such as tetanus and diarrhoea in this study.

As most neonatal illnesses have a limited repertoire of signs, many of them are non-specific, so a hierarchy of algorithm and its definitions should be maintained while assigning causes of death. On the other hand, medical personnel (physician/medical assistant) are usually knowledgeable about the disease profile of a geographical area and can use their clinical judgement and understanding when assigning causes of death. While they can diagnose cause of death for all ICD-10 codes by applying their clinical judgement, there is no algorithm available for allocation to many of the ICD-10 codes. This lack of diagnostic algorithm limits the comparison across methods for deriving causes of death.

Further research is needed to optimize the combination of using review by medical personnel and automated algorithmic methods to improve cause of death determination by VA methodology. However, regardless of the method, the accuracy of cause of death assignment will depend on the quality of information collected through the VA questionnaire. The use of a validation study using medically-confirmed gold standard diagnosis and the triangulation of methods would help refine the methods for ascribing causes of death and increase their reliability. There is a need for further research to develop a standardized VA tool.

Thirdly, programme managers can use epidemiological information derived from verbal autopsies to better plan programme interventions. For example, based on the information gathered from this study, birth asphyxia, prematurity/low birth weight and sepsis should be prioritised as the target of neonatal intervention packages. The great majority of neonatal deaths occurred either at the place of delivery or within 7 days of delivery. A competent skilled attendant and a postpartum care strategy could help protect newborns at their most vulnerable period.

Lack of antenatal care particularly during the last trimester, male sex of the newborn, single parity, no maternal education, and plurality of birth were found to be independently and significantly associated with a higher risk of neonatal mortality. Although institutional birth appeared to be associated with a higher risk of neonatal mortality, it is likely to have been due to the higher rate of complicated deliveries being referred to and then occurring at the health facilities. This study could not adjust for obstetric complications, but the increased proportion of such complications reported by mothers of deceased neonates suggests an association.

A greater emphasis on the importance of antenatal care and educating women to recognise signs and symptoms that require medical assessment could be instrumental in further improving neonatal survival. As suboptimal care is a concern in most maternity clinics in developing countries, education of maternity care personnel will benefit from a further focus on how to recognise and manage high-risk pregnancies and newborns. The epidemiological profile of neonatal deaths can vary between countries and regions, and the introduction of regular internal death audits and formative research could help in identifying avoidable risk factors for perinatal and neonatal deaths.

Fourthly, information on health care seeking during the fatal illnesses episode can be usefully adapted to more effectively utilize health care services. Community awareness about prompt care seeking, skilled attendance at delivery and integration of traditional care providers into mainstream health programmes may be an approach to reducing neonatal mortality in developing countries. However, more formative research at the local level is needed to understand the use and non-use of facilities for both delivery and newborn care. Findings from such research can help inform approaches for improving early recognition of danger signs, promoting demand for quality of care and overcoming socio-cultural barriers to referral.

Fifthly, strategies to improve child survival need to include promotion of maternal nutrition and health. Maternal nutrition status, in terms of pre-pregnancy weight, weight gained during pregnancy, and anaemia, is causally linked to intrauterine growth retardation and birth weight. Bangladesh has a very high incidence of low birth weight which contributes heavily to neonatal deaths. Prevention of low birth weight in Bangladesh requires intensive nutritional interventions to improve the general health and nutrition of women in the reproductive age group. However, these interventions need to be started much earlier, targeting girls. In that respect, the prevention of low birth weight should go beyond efforts such as ANC and home visits during pregnancy. Given the multi-factorial aetiology of low birth weight, a coordinated effort in both health and non-health sectors is necessary for improvement of women’s social and health status in order to reduce low birth weight and its related deaths. Efforts must include long-term strategies for improving women’s education, household authority and autonomy within the family.

Complications related to pregnancy can have enormous implications for the well-being of newborns. As the great majority of neonatal deaths were associated with complications during delivery and occurred at the place of delivery or shortly after delivery, universal access to skilled attendance at delivery especially at a health facility is key to reducing neonatal mortality.

Factors potentially amenable to intervention would be the reduction of maternal morbidity in the third trimester, or at least identification of conditions that are known to be important for timely referral. High risk pregnancies such as twin pregnancies should be identified for institutional delivery and subsequent care for newborns. Institutional delivery with particular emphasis on neonatal resuscitation and essential newborn care are likely to improve both neonatal and maternal survival. In addition, women who are not attending antenatal care but presenting late at institutions need to be targeted for rapid assessment upon presentation and for timely institutional delivery. More long term measures such as improving female education and access to family planning services would also have a direct effect on improving neonatal survival.

A package of integrated evidence-based preventive and curative services could be implemented, targeting pregnant women and newborns through a continuum of care approaches, from the community through to assessment of facilities. These activities should be implemented along with demand creation activities to facilitate the increased use of facility-based maternity care and newborn care services.

Counselling services should include education on breastfeeding, nutrition, hygienic delivery, birth preparedness plan including a transport plan, the importance of skilled delivery, postpartum care, danger signs for newborn, essential newborn care, danger signs and appropriate responses during pregnancy, delivery and postpartum period.

Identification of neonatal complications is not difficult and in most cases it can be successfully managed even in small facilities without skilled providers and sophisticated instruments or technology. The problem is timely recognition of the danger signs of newborn illness in the community and ensuring referral for prompt management.

Sub-standard health care is a concern in developing countries. Protocolized management of deliveries, birth asphyxia, prematurity/low birth weight (Kangaroo mother care) and sepsis at the community and at the health facility can improve the quality of care at the local level. Implementation of confidential enquiries and clinical audits for neonatal deaths and maternity and neonatal services can also improve the standards of care at health facilities (Bhutta et al. 2005; Filippi et al. 2006; Knippenberg et al. 2005; Koblinsky et al. 2006; Martines et al. 2005).

Sixthly, gender discrimination and great poverty coexist in Bangladesh and contribute to a large number of neonatal deaths either through limiting access to effective care or through increasing the magnitude of risk factors such as poor maternal nutrition and health. While improving the quality of services is important, it is not enough to improve access. Generally, medical professionals emphasize screening for biomedical problems over health education and promotion. Biomedical care should be complemented with health education and promotion to optimize the benefits of such care. Strategies and interventions that are efficient and benefit the poor such as a community-based skilled-birth-attendant programme and a voucher scheme for maternal health care services need to be implemented and evaluated to determine their impact on overcoming financial barrier as a means of reducing maternal and neonatal deaths. Addressing inequity should be a priority of all programme/strategies for improving survival of newborn babies.

Finally, while it is generally accepted that neonatal and infant mortality reflects the level of health and health care, they also reflect the socio-economic development of a country. The recommendations for reducing neonatal death require not just technical interventions, but also address cross cutting social and economic issues. The expectation is that appropriate primary care strategies like skilled attendance at delivery, newborn care and care of the sick newborn will result in reduced neonatal mortality. However, socio-economic and developmental factors limit access to, availability of and utilization of technical interventions. Therefore, substantial reductions in neonatal mortality require health programmes integrated with overall socio-economic development activities. A fairer distribution of global resources to reduce the poverty of the population in developing countries such as Bangladesh would have a major impact on achieving the MDG; for this the solutions are political and not biomedical.

BIBLIOGRAPHY

Afsana, K., and S. F. Rashid. 2000. Discoursing birthing care: experiences from Bangladesh. Dhaka, Bangladesh: University Press.

Afsana, K., and S. F. Rashid. 2001. The challenges of meeting rural Bangladeshi women's needs in delivery care. Reprod Health Matters 9 (18): 79-89.

Agarwal, K. N., D. K. Agarwal, and K. P. Mishra. 1991. Impact of anaemia prophylaxis in pregnancy on maternal haemoglobin, serum ferritin & birth weight. Indian J Med Res 94: 277-80.

Ahmed, S., M. A. Koenig, and R. Stephenson. 2006. Effects of domestic violence on perinatal and early-childhood mortality: evidence from north India. Am J Public Health 96 (8): 1423-8.

Ahmed, S., F. Sobhan, A. Islam, and Barket-e-Khuda. 2001. Neonatal morbidity and care-seeking behaviour in rural Bangladesh. J Trop Pediatr 47 (2): 98-105.

Ahmed, S. M., A. M. Adams, M. Chowdhury, and A. Bhuiya. 2003. Changing health-seeking behaviour in Matlab, Bangladesh: do development interventions matter? Health Policy Plan 18 (3): 306-15.

Alam, N., J. K. Van Ginneken, and A. M. Bosch. 2007. Infant mortality among twins and triplets in rural Bangladesh in 1975-2002. Trop Med Int Health 12 (12): 1506-14.

Altman, G. G. 1991. Practical Statistics for Medical Research. 1st edition ed. London: Chapman & Hall/CRC.

Amooti-Kaguna, B., and F. Nuwaha. 2000. Factors influencing choice of delivery sites in Rakai district of Uganda. Soc Sci Med 50 (2): 203-213.

Anker, M. 1997. The effect of misclassification error on reported cause-specific mortality fractions from verbal autopsy. Int J Epidemiol 26 (5): 1090-1096.

Anwar, I., M. Sami, N. Akhtar, M. Chowdhury, U. Salma, Rahman, and M. Koblinsky. 2008. Inequity in maternal health-care services: evidence from home-based skilled-birth-attendant programmes in Bangladesh. Bull World Health Organ 86 (4): 252-9.

Arifeen, S., R. Black, G. Antelman, A. Baqui, L. Caulfield, and S. Becker. 2001. Exclusive breastfeeding reduces acute respiratory infection and diarrhea deaths among infants in dhaka slums. Pediatrics 108 (4): E67.

Arifeen, S. E., R. E. Black, L. E. Caulfield, G. Antelman, and A. H. Baqui. 2001. Determinants of infant growth in the slums of Dhaka: Size and maturity at birth, breastfeeding and morbidity. Eur J Clin Nutr 55 (3): 167.

Asling-Monemi, K., R. Tabassum Naved, and L. A. Persson. 2008. Violence against women and the risk of under-five mortality: analysis of community-based data from rural Bangladesh. Acta Paediatr 97 (2): 226-32.

Atukorala, T. M., L. D. de Silva, W. H. Dechering, T. S. Dassenaeike, and R. S. Perera. 1994. Evaluation of effectiveness of iron-folate supplementation and anthelminthic therapy against anemia in pregnancy--a study in the plantation sector of Sri Lanka. Am J Clin Nutr 60 (2): 286-92.

Aziz, K. M. A. 1994. Matlab: Physical Setting and Cultural Background In Matlab: Women, Children and Health, ed. V. Fauveau, 1-460. Dhaka: International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B).

Bahl, R., C. Frost, B. R. Kirkwood, K. Edmond, J. Martines, N. Bhandari, and P. Arthur. 2005. Infant feeding patterns and risks of death and hospitalization in the first half of infancy: multicentre cohort study. Bull World Health Organ 83 (6): 418-26.

Bairagi, R., R. E. Black, J. Blacker, T. Boerma, U. Dalessandro, P. H. David, A. Defrancisco, A. Hill, K. Hill, H. Martinez, F. Midhet, B. Pelto, D. Ross, H. P. S. Sachdev, S. A. Wilopo, G. Stroh, M. Strong, B. Carlson, J. Gulaid, G. Jones, V. Orinda, J. C. Alary, M. Anker, M. A. Belsey, B. K. Nguyen, J. A. Cattani, C. J. Clements, H. Dixon, O. Fontaine, O. Frank, F. Gasse, M. Gersenovic, M. F. Gomes, S. Gove, H. R. Hapsara, J. P. Jardel, R. Kimfarley, S. Orzeszyna, P. Phillipshoward, S. Sapirie, P. Sato, P. M. Shah, E. A. Sherwin, S. Simeant, and R. Waldman. 1994. Measurement of Overall and Cause-Specific Mortality in Infants and Children - Memorandum from a WHO Unicef Meeting. Bull World Health Organ 72 (5): 707-713.

Bang, A. T., S. B. Baitule, H. M. Reddy, M. D. Deshmukh, and R. A. Bang. 2005. Low Birth Weight and Preterm Neonates: Can they be Managed at Home by Mother and a Trained Village Health Worker? J Perinatol 25 (S1): S72.

Bang, A. T., and R. A. Bang. 1992. Diagnosis of causes of childhood deaths in developing countries by verbal autopsy: suggested criteria. The SEARCH Team. Bull World Health Organ 70 (4): 499-507.

Bang, A. T., R. A. Bang, S. B. Baitule, H. M. Reddy, and M. D. Deshmukh. 2005. Management of Birth Asphyxia in Home Deliveries in Rural Gadchiroli: The Effect of Two Types of Birth Attendants and of Resuscitating with Mouth-to-Mouth, Tube-Mask or Bag-Mask. J Perinatol 25: S82-91.

Bang, A. T., R. A. Bang, S. B. Baitule, M. H. Reddy, and M. D. Deshmukh. 1999. Effect of home-based neonatal care and management of sepsis to reduce neonatal mortality: field trial in rural India. Lancet 354: 1955-61.

Bang, A. T., R. A. Bang, B. J. Stoll, S. B. Baitule, H. M. Reddy, and M. D. Deshmukh. 2005. Is home-based diagnosis and treatment of neonatal sepsis feasible and effective? Seven years of intervention in the Gadchiroli field trial (1996 to 2003). J Perinatol 25 (Suppl 1): S62-71.

Bang, A. T., V. K. Paul, H. M. Reddy, and S. B. Baitule. 2005. Why Do Neonates Die in Rural Gadchiroli, India? (Part I): Primary Causes of Death Assigned by Neonatologist Based on Prospectively Observed Records. J Perinatol 25 (S1): S29.

Bang, A. T., H. M. Reddy, R. A. Bang, and M. D. Deshmukh. 2005. Why do neonates die in rural Gadchiroli, India? (Part II): estimating population attributable risks and contribution of multiple morbidities for identifying a strategy to prevent deaths. J Perinatol 25 (Suppl 1): S35-43.

Bangladesh Bureau of Statistics (BBS). 2005. Statistical Yearbook of Bangladesh 2003. Dhaka, Bangladesh: BBS.

Baqui, A., R. Black, S. Arifeen, K. Hill, S. Mitra, and A. al Sabir. 1998. Causes of childhood deaths in Bangladesh: results of a nationwide verbal autopsy study. Bull World Health Organ 76 (2): 161.

Baqui, A. H., G. L. Darmstadt, E. K. Williams, V. Kumar, T. U. Kiran, D. Panwar, V. K. Srivastava, R. Ahuja, R. E. Black, and M. Santosham. 2006. Rates, timing and causes of neonatal deaths in rural India: implications for neonatal health programmes. Bull World Health Organ 84 (9): 706-13.

Baqui, A. H., A. A. Sabir, N. Begum, S. E. Arifeen, S. N. Mitra, and R. E. Black. 2001. Causes of childhood deaths in Bangladesh: an update. Acta Paediatr 90 (6): 682-90.

Bari, S., I. Mannan, M. A. Rahman, G. L. Darmstadt, M. H. Serajil, A. H. Baqui, S. El Arifeen, S. M. Rahman, S. K. Saha, A. S. Ahmed, S. Ahmed, M. Santosham, R. E. Black, and P. J. Winch. 2006. Trends in use of referral hospital services for care of sick newborns in a community-based intervention in Tangail District, Bangladesh. J Health Popul Nutr 24 (4): 519-29.

Bari, W., R. I. Chowdhury, M. A. Islam, N. Chakraborty, and H. A. Akhter. 2002. The differentials and determinants of perinatal mortality in rural Bangladesh. Eur J Contracept Reprod Health Care 7 (4): 216-22.

Barnett, S., K. Azad, S. Barua, M. Mridha, M. Abrar, A. Rego, A. Khan, D. Flatman, and A. Costello. 2006. Maternal and newborn-care practices during pregnancy, childbirth, and the postnatal period: a comparison in three rural districts in Bangladesh. J Health Popul Nutr 24 (4): 394-402.

Becker, S. 1981. Seasonality of deaths in Matlab, Bangladesh. Int J Epidemiol 10 (3): 271-80.

Becker, S., and S. Weng. 1998. Seasonal patterns of deaths in Matlab, Bangladesh. Int J Epidemiol 27 (5): 814-23.

Bell, J., J. Hussein, B. Jentsch, G. Scotland, C. Bullough, and W. Graham. 2003. Improving skilled attendance at delivery: a preliminary report of the SAFE strategy development tool. Birth 30 (4): 227-34.

Bhatia, S. 1989. Patterns and Causes of Neonatal and Postneonatal Mortality in Rural Bangladesh. Stud Fam Plann 20 (3): 136-146.

Bhutta, Z. A. 1999. Neonatal bacterial infections in developing countries: strategies for prevention. Semin Neonatol 4 (3): 159-171.

Bhutta, Z. A., G. L. Darmstadt, B. S. Hasan, and R. A. Haws. 2005. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. Pediatrics 115 (2 Suppl): 519-617.

Bhutta, Z. A., I. Gupta, H. De'Silva, D. Manandhar, S. Awasthi, S. M. M. Hossain, and M. A. Salam. 2004. Maternal and child health: is South Asia ready for change? BMJ 328: 816-819.

Bicego, G. T., and J. Ties Boerma. 1993. Maternal education and child survival: A comparative study of survey data from 17 countries. Soc Sci Med 36 (9): 1207-1227.

Black, R. E., S. S. Morris, and J. Bryce. 2003. Where and why are 10 million children dying every year? Lancet 361 (9376): 2226-2234.

Boulle, A., D. Chandramohan, and P. Weller. 2001. A case study of using artificial neural networks for classifying cause of death from verbal autopsy. Int J Epidemiol 30 (3): 515-520.

Bryce, J., C. Boschi-Pinto, K. Shibuya, and R. E. Black. 2005. WHO estimates of the causes of death in children. Lancet 365 (9465): 1147-1152.

Byass, P., E. Fottrell, L. H. Dao, Y. Berhane, T. Corrah, K. Kahn, L. Muhe, and D. V. Do. 2006. Refining a probabilistic model for interpreting verbal autopsy data. Scand J Public Health 34 (1): 26-31.

Byass, P., D. L. Huong, and H. V. Minh. 2003. A probabilistic approach to interpreting verbal autopsies: methodology and preliminary validation in Vietnam. Scand J Public Health Suppl 62: 32-7.

Caldwell, J., and P. McDonald. 1982. Influence of maternal education on infant and child mortality: levels and causes. Health Policy Educ 2 (3-4): 251-67.

Carroli, G., J. Villar, G. Piaggio, D. Khan-Neelofur, M. Gulmezoglu, M. Mugford, P. Lumbiganon, U. Farnot, and P. Bersgjo. 2001. WHO systematic review of randomised controlled trials of routine antenatal care. Lancet 357 (9268): 1565-1570.

Ceesay, S. M., A. M. Prentice, T. J. Cole, F. Foord, L. T. Weaver, E. M. Poskitt, and R. G. Whitehead. 1997. Effects on birth weight and perinatal mortality of maternal dietary supplements in rural Gambia: 5 year randomised controlled trial. BMJ 315 (7111): 786-90.

Chandramohan, D., G. H. Maude, L. C. Rodrigues, and R. J. Hayes. 1994. Verbal autopsies for adult deaths: issues in their development and validation. Int J Epidemiol 23 (2): 213-22.

Chen, L. C., E. Huq, and S. D'Souza. 1981. Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh. Popul Dev Rev 7 (1): 55-70.

Chowdhury, M. E., H. H. Akhter, V. Chongsuvivatwong, and A. F. Geater. 2005. Neonatal mortality in rural Bangladesh: an exploratory study. J Health Popul Nutr 23 (1): 16-24.

Chowdhury, M. E., R. Botlero, M. Koblinsky, S. K. Saha, G. Dieltiens, and C. Ronsmans. 2007. Determinants of reduction in maternal mortality in Matlab, Bangladesh: a 30-year cohort study. Lancet 370 (9595): 1320-8.

Chowdhury, M. E., C. Ronsmans, J. Killewo, I. Anwar, K. Gausia, S. Das-Gupta, L. S. Blum, G. Dieltiens, T. Marshall, S. Saha, and J. Borghi. 2006. Equity in use of home-based or facility-based skilled obstetric care in rural Bangladesh: an observational study. Lancet 367 (9507): 327-332.

Christensson, K., G. J. Bhat, B. C. Amadi, B. Eriksson, and B. Hojer. 1998. Randomised study of skin-to-skin versus incubator care for rewarming low-risk hypothermic neonates. Lancet 352 (9134): 1115.

Conde-Agudelo, A., J. L. Diaz-Rossello, and J. M. Belizan. 2003. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. Cochrane Database Syst Rev (2): CD002771.

Cruz-Anguiano, V., J. O. Talavera, L. Vazquez, A. Antonio, A. Castellanos, M. A. Lezana, and N. H. Wacher. 2004. The importance of quality of care in perinatal mortality: a case-control study in Chiapas, Mexico. Arch Med Res 35 (6): 554-562.

Darmstadt, G. L., Z. A. Bhutta, S. Cousens, T. Adam, N. Walker, and L. de Bernis. 2005. Evidence-based, cost-effective interventions: how many newborn babies can we save? Lancet 365 (9463): 977-988.

Darmstadt, G. L., R. E. Black, and M. Santosham. 2000. Research priorities and postpartum care strategies for the prevention and optimal management of neonatal infections in less developed countries. Pediatr Infect Dis J 19 (8): 739-50.

Darmstadt, G. L., V. Kumar, R. Yadav, V. Singh, P. Singh, S. Mohanty, A. H. Baqui, N. Bharti, S. Gupta, R. P. Misra, S. Awasthi, J. V. Singh, M. Santosham, and T. Saksham Study Group. 2006. Introduction of community-based skin-to-skin care in rural Uttar Pradesh, India. J Perinatol 26(10): 597-604.

Darmstadt, G. L., J. E. Lawn, and A. Costello. 2003. Advancing the state of the world's newborns. Bull World Health Organ 81 (3): 224-5.

Darmstadt, G. L., A. S. Nawshad Uddin Ahmed, S. K. Saha, M. A. Azad Chowdhury, M. A. Alam, M. Khatun, R. E. Black, and M. Santosham. 2005. Infection control practices reduce nosocomial infections and mortality in preterm infants in Bangladesh. J Perinatol 25 (5): 331-5.

Darmstadt, G. L., S. K. Saha, A. S. Ahmed, M. A. Chowdhury, P. A. Law, S. Ahmed, M. A. Alam, R. E. Black, and M. Santosham. 2005. Effect of topical treatment with skin barrier-enhancing emollients on nosocomial infections in preterm infants in Bangladesh: a randomised controlled trial. Lancet 365 (9464): 1039-45.

Darmstadt, G. L., U. Syed, Z. Patel, and N. Kabir. 2006. Review of domiciliary newborn-care practices in Bangladesh. J Health Popul Nutr 24 (4): 380-93.

Dawson, B., and R. G. Trapp. 2004. Basic & Clinical Biostatistics. 4th ed. Singapore: McGraw-Hill Companies, Inc.

de Lange, T. E., M. P. Budde, A. R. Heard, G. Tucker, R. Kennare, and G. A. Dekker. 2008. Avoidable risk factors in perinatal deaths: A perinatal audit in South Australia. Aust N Z J Obstet Gynaecol 48 (1): 50-7.

de Onis, M., M. Blossner, and J. Villar. 1998. Levels and patterns of intrauterine growth retardation in developing countries. Eur J Clin Nutr 52 Suppl 1: S5-15.

Defo, B. K. 1996. Areal and socioeconomic differentials in infant and child mortality in Cameroon. Soc Sci Med 42 (3): 399-420.

Dilenge, M. E., A. Majnemer, and M. I. Shevell. 2001. Long-term developmental outcome of asphyxiated term neonates. J Child Neurol 16 (11): 781-92.

Edmond, K. M., C. Zandoh, M. A. Quigley, S. Amenga-Etego, and e. al. 2006. Delayed Breastfeeding Initiation Increases Risk of Neonatal Mortality. Pediatrics 117 (3): 905.

Ellis, M., and D. Manandhar. 1999. Progress in perinatal asphyxia. Semin Neonatol 4 (3): 183-191.

Eshleman, M., V. Poole, and R. Davidhizar. 2005. An investigation of factors associated with infant mortality in two midwest counties. J Pract Nurs 55 (3): 5.

Fantahun, M., E. Fottrell, Y. Berhane, S. Wall, U. Hogberg, and P. Byass. 2006. Assessing a new approach to verbal autopsy interpretation in a rural Ethiopian community: the InterVA model. Bull World Health Organ 84 (3): 204-10.

Fauveau, V. 2006. Assessing probable causes of death without death registration or certificates: a new science? Bull World Health Organ 84 (3): 246-7.

Fauveau, V., and J. Chakraborty. 1994. Family Planning and Maternal and Child Health Services in Matlab. In Matlab: Women, Children and Health, ed. V. Fauveau, 1-460. Dhaka: International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B).

Fauveau, V., B. Wojtyniak, H. R. Chowdhury, and A. M. Sarder. 1991. An assessment of causes of death in the Matlab Demographic Surveillance System. Edited by P. W. Brass. Vol. Research Paper 91-1. 99 Gower Street, London: Centre for Population Studies, London School of Hygiene & Tropical Medicine.

Fauveau, V., B. Wojtyniak, G. Mostafa, A. M. Sarder, and J. Chakraborty. 1990. Perinatal mortality in Matlab, Bangladesh: a community-based study. Int J Epidemiol 19 (3): 606-12.

Feresu, S. A., S. D. Harlow, K. Welch, and B. W. Gillespie. 2005. Incidence of stillbirth and perinatal mortality and their associated factors among women delivering at Harare Maternity Hospital, Zimbabwe: a cross-sectional retrospective analysis. BMC Pregnancy Childbirth 5 (1): 9.

Fikree, F. F., S. I. Azam, and H. W. Berendes. 2002. Time to focus child survival programmes on the newborn: assessment of levels and causes of infant mortality in rural Pakistan. Bull World Health Organ 80 (4): 271-276.

Filippi, V., C. Ronsmans, O. M. Campbell, W. J. Graham, A. Mills, J. Borghi, M. Koblinsky, and D. Osrin. 2006. Maternal health in poor countries: the broader context and a call for action. Lancet 368 (9546): 1535-41.

Frank, B., B. Ayaga, B. Sidu, B. Fred, and et al. 2007. Setting international standards for verbal autopsy. World Health Organization. Bull World Health Organ 85 (8): 570.

Freeman, J. V., P. Christian, S. K. Khatry, R. K. Adhikari, S. C. Leclerq, J. Katz, and G. L. Darmstadt. 2005. Evaluation of neonatal verbal autopsy using physician review versus algorithm-based cause-of-death assignment in rural Nepal. Paediatr Perinat Epidemiol 19 (4): 323-331.

Garenne, M., and V. Fauveau. 2006. Potential and limits of verbal autopsies. Bull World Health Organ 84 (3): 164.

Gazi, R., L. Goodburn, and A. M. Chowdhury. 1999. Risk factors for perinatal deaths in rural Bangladesh. J Health Popul Dev Ctries 2 (1): 70-7.

Goodburn, E., M. Chowdhury, and R. Gazi. 1994. Low birth weight in rural Bangladesh. J Trop Pediatr 40 (2): 123.

Gordis, L. 2004. Epidemiology. 3rd ed. Pennsylvania: Elservier Saunders.

Government of the People's Republic of Bangladesh, WHO, and UNICEF. 2001. Integrated Management of Childhood Illness: Managemnt of the Sick Young Infant Age 1 Day Up to 2 Months. Dhaka: Goverenment of the People's Republic of Bangladesh, WHO and UNICEF.

Haider, R., A. Ashworth, I. Kabir, and S. R. Huttly. 2000. Effect of community-based peer counsellors on exclusive breastfeeding practices in Dhaka, Bangladesh: a randomised controlled trial. Lancet 356 (9242): 1643-1647.

Hale, L., J. DaVanzo, A. Razzaque, and M. Rahman. 2006. Why are infant and child mortality rates lower in the MCH-FP area of Matlab, Bangladesh? Stud Fam Plann 37 (4): 281-92.

Hawkes, S., L. Morison, J. Chakraborty, K. Gausia, F. Ahmed, S. S. Islam, N. Alam, D. Brown, and D. Mabey. 2002. Reproductive tract infections: prevalence and risk factors in rural Bangladesh. Bull World Health Organ 80 (3): 180-8.

HDSS-Matlab. 2007. Health and Demographic Surveillance System-Matlab: volume 39. Registration of health and demographic events 2005 [SR97, 2007] Dhaka: ICDDR,B.

HDSS-Matlab: 2005 socio-economic census. 2007. Health and Demographic Surveillance System-Matlab: volume 38. 2005 socio-economic census [SR96, 2007] Dhaka: International Centre for Diarrhoeal Disease Resaerch, Bangladesh (ICDDR,B).

HDSS. 2002. Health and Demographic Surveillance System - Matlab: Registration of Health and Demographic Events 2000. Dhaka, Bangladesh: ICDDR,B: Centre for Health and Population Research.

HDSS. 2004. Health and Demographic Surveillance System - Matlab: Registration of Health and Demographic Events 2002. Dhaka: ICDDR,B: Centre for Health and Population Research.

Hong, R. 2006. Effect of multiple birth on infant mortality in Bangladesh. J Paediatr Child Health 42 (10): 630-5.

Hong, R., and M. Ruiz-Beltran. 2007. Impact of prenatal care on infant survival in Bangladesh. Matern Child Health J 11 (2): 199-206.

Hosain, G. M., N. Chatterjee, A. Begum, and S. C. Saha. 2006. Factors associated with low birthweight in rural Bangladesh. J Trop Pediatr 52 (2): 87-91.

Hossain, M. B., J. F. Phillips, and B. Pence. 2007. The effect of women's status on infant and child mortality in four rural areas of Bangladesh. J Biosoc Sci 39 (3): 355.

Huffman, S. L., E. R. Zehner, and C. Victora. 2001. Can improvements in breast-feeding practices reduce neonatal mortality in developing countries? Midwifery 17 (2): 80-92.

Humphrey, M. D., and S. M. Keating. 2004. Lack of antenatal care in far north Queensland. Aust N Z J Obstet Gynaecol 44 (1): 10-13.

Huong, D. L., H. V. Minh, and P. Byass. 2003. Applying verbal autopsy to determine cause of death in rural Vietnam. Scand J Public Health Suppl 62: 19-25.

Hurt, L. S., N. Alam, G. Dieltiens, N. Aktar, and C. Ronsmans. 2008. Duration and magnitude of mortality after pregnancy in rural Bangladesh. Int J Epidemiol 37 (2): 397-404.

Hyder, A. A., S. A. Wali, and J. McGuckin. 2003. The burden of disease from neonatal mortality: a review of South Asia and Sub-Saharan Africa. BJOG 110 (10): 894-901.

ICDDRB. 2003. Annual Report. Dhaka: ICDDR,B: Centre for Health and Population Research.

ICDDRB Web Page. http://www.icddrb.org (accessed December 20, 2007).

INDEPTH Network. http://www.indepth-network.org (accessed December 20, 2007).

Jackson, A. A., Z. A. Bhutta, and P. Lumbiganon. 2003. Nutrition as a preventative strategy against adverse pregnancy outcomes. J Nutr 133 (5 Suppl 2): 1589S-1591S.

Jaffar, S., A. Leach, A. M. Greenwood, A. Jepson, O. Muller, M. O. Ota, K. Bojang, S. Obaro, and B. M. Greenwood. 1997. Changes in the pattern of infant and childhood mortality in upper river division, The Gambia, from 1989 to 1993. Trop Med Int Health 2 (1): 28-37.

Joyce, R., R. Webb, and J. Peacock. 2004. Associations between perinatal interventions and hospital stillbirth rates and neonatal mortality. Arch Dis Child Fetal Neonatal Ed 89 (1): F51.

Kahn, K., S. M. Tollman, M. Garenne, and J. S. Gear. 2000. Validation and application of verbal autopsies in a rural area of South Africa. Trop Med Int Health 5 (11): 824-831.

Kalter, H. D., R. H. Gray, R. E. Black, and S. A. Gultiano. 1990. Validation of Postmortem Interviews to Ascertain Selected Causes of Death in Children. Int J Epidemiol 19 (2): 380-386.

Kalter, H. D., R. H. Gray, R. E. Black, and S. A. Gultiano. 1991. Validation of the Diagnosis of Childhood Morbidity Using Maternal Health Interviews. Int J Epidemiol 20 (1): 193-198.

Kalter, H. D., M. Hossain, G. Burnham, N. Z. Khan, S. K. Saha, M. A. Ali, and R. E. Black. 1999. Validation of caregiver interviews to diagnose common causes of severe neonatal illness. Paediatr Perinat Epidemiol 13 (1): 99-113.

Katz, J., J. Keith P West, S. K. Khatry, S. C. LeClerq, P. Christian, E. K. Pradhan, and S. R. Shrestha. 2001. Twinning rates and survival of twins in rural Nepal. Int J Epidemiol 30 (4): 802.

Killewo, J., I. Anwar, I. Bashir, M. Yunus, and J. Chakraborty. 2006. Perceived delay in healthcare-seeking for episodes of serious illness and its implications for safe motherhood interventions in rural Bangladesh. J Health Popul Nutr 24 (4): 403-12.

Knippenberg, R., J. E. Lawn, G. L. Darmstadt, G. Begkoyian, H. Fogstad, N. Walelign, and V. K. Paul. 2005. Systematic scaling up of neonatal care in countries. Lancet 365 (9464): 1087-1098.

Koblinsky, M., Z. Matthews, J. Hussein, D. Mavalankar, M. K. Mridha, I. Anwar, E. Achadi, S. Adjei, P. Padmanabhan, B. Marchal, V. De Brouwere, and W. van Lerberghe. 2006. Going to scale with professional skilled care. Lancet 368 (9544): 1377-86.

Kramer, M. S. 1987. Determinants of low birth weight: methodological assessment and meta-analysis. Bull World Health Organ 65 (5): 663-737.

Kusiako, T., C. Ronsmans, and L. Van der Paal. 2000. Perinatal mortality attributable to complications of childbirth in Matlab, Bangladesh. Bull World Health Organ 78 (5): 621-7.

Kynast-Wolf, G., G. P. Hammer, O. Muller, B. Kouyate, and H. Becher. 2006. Season of death and birth predict patterns of mortality in Burkina Faso. Int J Epidemiol 35 (2): 427-35.

Lawn, J., K. Shibuya, and C. Stein. 2005. No cry at birth: global estimates of intrapartum stillbirths and intrapartum-related neonatal deaths. Bull World Health Organ 83 (6): 409.

Lawn, J. E., S. Cousens, Z. A. Bhutta, G. L. Darmstadt, and e. al. 2004. Why are 4 million newborn babies dying each year? Lancet 364 (9432): 399.

Lawn, J. E., S. Cousens, and J. Zupan. 2005. 4 million neonatal deaths: When? Where? Why? Lancet 365 (9462): 891-900.

Lucas, G. N., and R. C. Ediriweera. 1996. Perinatal deaths at the Castle Street Hospital for Women in 1993. Ceylon Med J 41 (1): 10-2.

Mancey-Jones, M., and R. Brugha. 1997. Review article. Using perinatal audit to promote change: a review 10.1093/heapol/12.3.183. Health Policy Plan. 12 (3): 183-192.

Marsh, D. R., S. Sadruddin, F. F. Fikree, C. Krishnan, and G. L. Darmstadt. 2003. Validation of verbal autopsy to determine the cause of 137 neonatal deaths in Karachi, Pakistan. Paediatr Perinat Epidemiol 17 (2): 132-142.

Martines, J., V. K. Paul, Z. A. Bhutta, M. Koblinsky, A. Soucat, N. Walker, R. Bahl, H. Fogstad, and A. Costello. 2005. Neonatal survival: a call for action. Lancet 365 (9465): 1189-1197.

McCall, E. M., F. A. Alderdice, H. L. Halliday, J. G. Jenkins, and S. Vohra. 2005. Interventions to prevent hypothermia at birth in preterm and/or low birthweight babies. Cochrane Database Syst Rev (1): CD004210.

McClure, E. M., R. L. Goldenberg, N. Brandes, G. L. Darmstadt, and L. L. Wright. 2007. The use of chlorhexidine to reduce maternal and neonatal mortality and morbidity in low-resource settings. Int J Gynaecol Obstet 97 (2): 89-94.

McDonagh, M. 1996. Is antenatal care effective in reducing maternal morbidity and mortality? Health Policy Plan 11 (1): 1-15.

Mercer, A., F. Haseen, N. L. Huq, N. Uddin, M. Hossain Khan, and C. P. Larson. 2006. Risk factors for neonatal mortality in rural areas of Bangladesh served by a large NGO programme. Health Policy Plan 21 (6): 432-43.

Mercer, A., M. H. Khan, M. Daulatuzzaman, and J. Reid. 2004. Effectiveness of an NGO primary health care programme in rural Bangladesh: evidence from the management information system. Health Policy Plan 19 (4): 187.

Mercer, A., N. Uddin, N. L. Huq, F. Haseen, M. H. Khan, and C. P. Larson. 2006. Validating neonatal mortality and use of NGO reproductive health outreach services in rural Bangladesh. Stud Fam Plann 37 (2): 111-22.

Mesko, N., D. Osrin, S. Tamang, B. P. Shrestha, D. S. Manandhar, M. Manandhar, H. Standing, and A. M. Costello. 2003. Care for perinatal illness in rural Nepal: a descriptive study with cross-sectional and qualitative components. BMC Int Health Hum Rights 3 (1): 3.

Mirza, N. M., W. M. Macharia, E. M. Wafula, R. O. Agwanda, and F. E. Onyango. 1990. Verbal autopsy: a tool for determining cause of death in a community. East Afr Med J 67 (10): 693-8.

Mobley, C. C., J. T. Boerma, S. Titus, B. Lohrke, K. Shangula, and R. E. Black. 1996. Validation study of a verbal autopsy method for causes of childhood mortality in Namibia. J Trop Pediatr 42 (6): 365-9.

Mohsin, M., A. E. Bauman, and B. Jalaludin. 2006. The influence of antenatal and maternal factors on stillbirths and neonatal deaths in New South Wales, Australia. J Biosoc Sci 38 (5): 643.

Moore, S. E., A. J. C. Fulford, P. K. Streatfield, L. A. Persson, and A. M. Prentice. 2004. Comparative analysis of patterns of survival by season of birth in rural Bangladeshi and Gambian populations. Int J Epidemiol 33 (1): 137-143.

Moss, W., G. L. Darmstadt, D. R. Marsh, R. E. Black, and M. Santosham. 2002. Research Priorities for the Reduction of Perinatal and Neonatal Morbidity and Mortality in Developing Country Communities. J Perinatol 22 (6): 484.

Moyo, S., T. Hawkridge, H. Mahomed, L. Workman, D. Minnies, L. J. Geiter, S. Verver, M. Kibel, and G. D. Hussey. 2007. Determining causes of mortality in children enrolled in a vaccine field trial in a rural area in the Western Cape Province of South Africa. J Paediatr Child Health 43 (3): 178-83.

Murray, C. J., and A. D. Lopez. 1997. Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet 349 (9061): 1269-1276.

Narayanan, I., K. Prakash, N. S. Murthy, and V. V. Gujral. 1984. Randomised controlled trial of effect of raw and holder pasteurised human milk and of formula supplements on incidence of neonatal infection. Lancet 2 (8412): 1111-3.

National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro. 2001. Bangladesh Demographic and Health Survey 1999-2000. Dhaka, Bangladesh; Claverton, Maryland (USA): National Institute of Population Research and Training (NIPORT), Mitra and Associate and ORC Macro. http://www.measureedhs.com (accessed October 30, 2006).

National Institute of Population Research and Training (NIPORT), Mitra and Associate, and ORC Macro. 2005. Bangladesh Demographic and Health Survey 2004. Dhaka, Bangladesh; Calverton, Maryland(USA): National Institute of Population Research and Training (NIPORT),Mitra and Associate and ORC Macro,. www.measuredhs.com (accessed October 30, 2006).

National Institute of Population Research and Training (NIPORT), ORC Macro, Johns Hopkins University Baltimore Maryland USA, and B. ICDDR. 2003. Bangladesh Maternal Health Services and Maternal Mortality Survey 2001. Dhaka, Bangladesh; Claverton, Maryland (USA): NIPORT,ORC Macro, Johns Hopkins University and ICDDR,B. www.measuredhs.com (accessed October 30, 2006).

Oxfam International Briefing Paper. 2004. Towards ending violence against women in South Asia (briefing paper 66). http://www.oxfam.org/en/policy/briefingpapers/bp66_violence_against_women_sasia (accessed November 2, 2007).

Parker, R. L. 2005. Guest Editorial for Journal of Perinatology Supplement on the Gadchiroli Field Trial. J Perinatol 25 (S1): S1.

Parkhurst, J. O., S. A. Rahman, and F. Ssengooba. 2006. Overcoming access barriers for facility-based delivery in low-income settings: insights from Bangladesh and Uganda. J Health Popul Nutr 24 (4): 438-45.

Patel, Z., V. Kumar, P. Singh, V. Singh, R. Yadav, A. H. Baqui, M. Santosham, S. Awasthi, J. V. Singh, and G. L. Darmstadt. 2007. Feasibility of community neonatal death audits in rural Uttar Pradesh, India. J Perinatol 27 (9): 556.

PATH. 2006. Reducing Birth Asphyxia Through the Bidan di Desa Program in Cirebon, Indonesia: Final Report Submitted by Program for Appropriate Technology in Health (PATH) to Save the Children US. Jakarta, Indonesia: Appropriate Technology in Health (PATH) http://www.icddrb.org/pub/publication.jsp?classificationID=68&pubID=7512 (accessed October 31, 2007).

Paul, B. K., and D. J. Rumsey. 2002. Utilization of health facilities and trained birth attendants for childbirth in rural Bangladesh: an empirical study. Soc Sci Med 54 (12): 1755-1765.

Paul, V. K. 1999. Newborn care in India: a promising beginning, but a long way to go. Semin Neonatol 4 (3): 141-149.

Pena, R., S. Wall, and L. Persson. 2000. The effect of poverty, social inequity, and maternal education on infant mortality in Nicaragua, 1988-1993. Am J Public Health 90 (1): 64.

Peterson, S., J. Nsungwa-Sabiiti, W. Were, X. Nsabagasani, G. Magumba, J. Nambooze, and G. Mukasa. 2004. Coping with paediatric referral--Ugandan parents' experience. Lancet 363 (9425): 1955-1956.

Piyush, G., R. Mily, D. Tarun, R. Gita, and et al. 2007. Multimicronutrient Supplementation for Undernourished Pregnant Women and the Birth Size of Their Offspring. Arch Pediatr Adolesc Med 161 (1): 58.

Prentice, A. M., R. G. Whitehead, M. Watkinson, W. H. Lamb, and T. J. Cole. 1983. Prenatal dietary supplementation of African women and birth-weight. Lancet 1 (8323): 489-92.

Quasem, I., N. L. Sloan, A. Chowdhury, S. Ahmed, B. Winikoff, and A. M. Chowdhury. 2003. Adaptation of kangaroo mother care for community-based application. J Perinatol 23 (8): 646-51.

Quigley, M. A., J. R. Armstrong Schellenberg, and R. W. Snow. 1996. Algorithms for verbal autopsies: a validation study in Kenyan children. Bull World Health Organ 74 (2): 147-54.

Quigley, M. A., D. Chandramohan, and L. C. Rodrigues. 1999. Diagnostic accuracy of physician review, expert algorithms and data-derived algorithms in adult verbal autopsies. Int J Epidemiol 28 (6): 1081.

Quigley, M. A., D. Chandramohan, P. Setel, F. Binka, and L. C. Rodrigues. 2000. Validity of data-derived algorithms for ascertaining causes of adult death in two African sites using verbal autopsy. Trop Med Int Health 5 (1): 33-39.

Rahman, A., M. Vahter, E. C. Ekstrom, M. Rahman, A. H. Golam Mustafa, M. A. Wahed, M. Yunus, and L. A. Persson. 2007. Association of arsenic exposure during pregnancy with fetal loss and infant death: a cohort study in Bangladesh. Am J Epidemiol 165 (12): 1389-96.

Rahman, M., and J. DaVanzo. 1993. Gender preference and birth spacing in Matlab, Bangladesh. Demography 30 (3): 315.

Rahman, R. M. 2006. Human rights, health and the state in Bangladesh. BMC Int Health Hum Rights 6: 4.

Rahman, S., and F. Nessa. 1989. Neo-natal mortality patterns in rural Bangladesh. J Trop Pediatr 35 (4): 199-202.

Ramji, S., R. Rasaily, P. K. Mishra, A. Narang, S. Jayam, A. Kapoor, I. Kambo, A. Mathur, N. C. Saxena, and B. Saxena. 2003. Resuscitation of asphyxiated newborns with room air or 100% oxygen at birth: A multicentric clinical trial. Indian Pediatr 40: 510-517.

Razzaque, A., P. K. Streatfield, and D. R. Gwatkin. 2007. Does health intervention improve socioeconomic inequalities of neonatal, infant and child mortality? Evidence from Matlab, Bangladesh. Int J Equity Health 6: 4.

Ronsmans, C., and W. J. Graham. 2006. Maternal mortality: who, when, where, and why. Lancet 368 (9542): 1189-200.

Salam, A. K. M. A., F. Haseen, H. K. M. Yusuf, and H. Torlesse. 2006. National Low Birth-weight Survey of Bangladesh, 2003-2004 In 8th Commonwealth Congress on Diarrhoea and Malnutrition (CAPGAN) Dhaka. ICDDR,B: Centre for Health and Population Research.

Samuel, L. 2007. Scientists tackle water contamination in Bangladesh. Lancet 370 (9586): 471.

Sazawal, S., and R. E. Black. 2003. Effect of pneumonia case management on mortality in neonates, infants, and preschool children: a meta-analysis of community-based trials. Lancet Infect Dis 3 (9): 547-556.

Setel, P. W., C. Rao, Y. Hemed, D. R. Whiting, G. Yang, D. Chandramohan, K. G. Alberti, and A. D. Lopez. 2006. Core verbal autopsy procedures with comparative validation results from two countries. PLoS Med 3 (8): e268. PubMed. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16942391 (accessed December 1, 2006).

Setel, P. W., D. R. Whiting, Y. Hemed, D. Chandramohan, L. J. Wolfson, K. G. Alberti, and A. D. Lopez. 2006. Validity of verbal autopsy procedures for determining cause of death in Tanzania. Trop Med Int Health 11 (5): 681-96.

Shaheen, R., A. de Francisco, S. El Arifeen, E. C. Ekstrom, and L. A. Persson. 2006. Effect of prenatal food supplementation on birth weight: an observational study from Bangladesh. Am J Clin Nutr 83 (6): 1355-61.

Shrestha, M., D. S. Manandhar, S. Dhakal, and N. Nepal. 2006. Two year audit of perinatal mortality at Kathmandu Medical College Teaching Hospital. Kathmandu Univ Med J (KUMJ) 4 (14): 176-181.

Shrivastava, S. P., A. Kumar, and A. Kumar Ojha. 2001. Verbal autopsy determined causes of neonatal deaths. Indian Pediatr 38 (9): 1022-5.

Sibley, L., and T. Ann Sipe. 2004. What can a meta-analysis tell us about traditional birth attendant training and pregnancy outcomes? Midwifery 20 (1): 51-60.

Silverman, J. G., J. Gupta, M. R. Decker, N. Kapur, and A. Raj. 2007. Intimate partner violence and unwanted pregnancy, miscarriage, induced abortion, and stillbirth among a national sample of Bangladeshi women. BJOG 114 (10): 1246.

Snow, R. W., J. R. M. Armstrong, and et. al. 1992. Childhood Deaths in Africa: Uses and Limitations of Verbal Autopsies. Lancet 340 (8815): 351.

Soleman, N., D. Chandramohan, and K. Shibuya. 2006. Verbal autopsy: current practices and challenges. Bull World Health Organ 84 (3): 239-45.

StataCorp. 2005. Stata Statistical Software:Release 9. College Station, TX: SataCorp LP.

Syed, U., S. Asiruddin, M. S. Helal, Mannan, II, and J. Murray. 2006. Immediate and early postnatal care for mothers and newborns in rural Bangladesh. J Health Popul Nutr 24 (4): 508-18.

Thaddeus, S., and D. Maine. 1994. Too far to walk: Maternal mortality in context. Soc Sci Med 38 (8): 1091-1110.

Todd, J., R. Balira, H. Grosskurth, P. Mayaud, F. Mosha, G. ka-Gina, A. Klokke, R. Gabone, A. Gavyole, D. Mabey, and R. Hayes. 1997. HIV-associated adult mortality in a rural Tanzanian population. Aids 11 (6): 801-7.

Todd, J. E., A. De Francisco, T. J. O'Dempsey, and B. M. Greenwood. 1994. The limitations of verbal autopsy in a malaria-endemic region. Ann Trop Paediatr 14 (1): 31-6.

Travis, P., S. Bennett, A. Haines, T. Pang, Z. Bhutta, A. A. Hyder, N. R. Pielemeier, A. Mills, and T. Evans. 2004. Overcoming health-systems constraints to achieve the Millennium Development Goals. Lancet 364 (9437): 900-906.

Ulizzi, L., and L. A. Zonta. 2002. Sex differential patterns in perinatal deaths in Italy. Hum Biol 74 (6): 879.

United Nations Children Fund. 2006. The State of the World's Children 2006. http://www.unicef.org/sowc06/statistics/statistics.php (accessed July 10, 2007).

United Nations Millennium Declaration. 2000. United Nations General Assembly Resolution 55/2. http://www.un.org/millennium/declaration/ares552e.htm (accessed July 9, 2007).

Unnati Rani, S., and B. Radheshyam. 2007. Inconsistencies in the Relationship Between Contraceptive Use and Fertility in Bangladesh. Int Fam Plan Perspect 33 (1): 31.

Vanneste, A. M., C. Ronsmans, J. Chakraborty, and A. De Francisco. 2000. Prenatal screening in rural Bangladesh: from prediction to care. Health Policy Plan 15 (1): 1-10.

Velaphi, S., and R. Pattinson. 2007. Avoidable factors and causes of neonatal deaths from perinatal asphyxia-hypoxia in South Africa: national perinatal survey. Ann Trop Paediatr 27 (2): 99.

Victoria, C. G., S. R. A. Huttly, F. C. Barros, C. Lombardi, and J. P. Vaughan. 1992. Maternal education in relation to early and late child health outcomes: Findings from a Brazilian cohort study. Soc Sci Med 34 (8): 899-905.

Wardlaw, T. 2004. Low Birthweight: Country, Regional and Global Estimates. New York: United Nations Children Fund and World Health Organizarion. http://www.unicef.org/publications/index_24840.html (accessed June 8, 2007).

Weiner, R., C. Ronsmans, E. Dorman, H. Jilo, A. Muhoro, and C. Shulman. 2003. Labour complications remain the most important risk factors for perinatal mortality in rural Kenya. Bull World Health Organ 81 (8): 561-6.

Wells, J. C. K. 2000. Natural Selection and Sex Differences in Morbidity and Mortality in Early Life. J Theor Biol 202 (1): 65-76.

WHO. 1978. Lay reporting of health information. Geneva: World Health Organization.

WHO. 1993. International Statistical Classification of Diseases and Related Health Problems. Tenth Revision. Vol. 2. Geneva: World Health Organization.

WHO. 1994. Mother-Baby Package: Implementing safe motherhood in countries Geneva, Switzerland: Maternal Health and Safe Motherhood Programme. http://www.who.int/reproductive-health/publications/MSM_94_11/mother_baby_package_safe_motherhood.pdf (accessed July 18, 2007).

WHO. 1997. Basic newborn resuscitation: A practical guide. World Health Organization, 1997. http://www.who.int/reproductive-health/publications/newborn_resuscitation/index.html (accessed October 29, 2007).

WHO. 1997. Thermal protection of newborn: a practical guide (WHO/RHT/MSM/97.2). Geneva: World Health Organization. http://www.who.int/reproductive-health/publications/MSM_97_2_Thermal_protection_of_the_newborn/MSM_97_2_annex.en.html (accessed July 22, 2007).

WHO. 1999. A standard verbal autopsy method for investigating causes of death in infants and children. http://www.who.int/csr/resources/publications/surveillance/WHO_CDS_CSR_ISR_99_4/en/ (accessed November 1, 2007).

WHO. 1999. Health Situation in South-East Asia Region, 1998-1999. http://www.searo.who.int/LinkFiles/Health_Situation_sec-b_chap-4.pdf (accessed July 2, 2007).

WHO. 2000. Management of the child with a serious infection or a severe malnutrition: guidelines for care of the first referral level in developing countries. Geneva: Department of Child and Adolescent Health and Development, WHO & UNICEF.

WHO. 2001. Integrated Management of Childhood illness(IMCI): Management of the sick young infant age 1 day upto 2 months. Dhaka: Government of the People's Republic of Bangladesh.

WHO. 2002. Improving Neonatal Health in South-East Asia Region. http://whqlibdoc.who.int/searo/2002/SEA_MCH_219.pdf (accessed December 20, 2007).

WHO. 2003. Antenatal care in developing countries: propises, achievements and missed opportunities:an analysisof trends, levels and differentials, 1990-2001. Geneva: World Health Organization. http://www.who.int/reproductive-health/docs/antenatal_care.pdf (accessed April 12, 2007).

WHO. 2005. WHO technical consultation on verbal autopsy tools. Geneva: World Health Organization. http://www.who.int/healthinfo/statistics/mort_verbalautopsy.pdf (accessed July 2, 2007).

WHO. 2005. The World Health Report 2005. Make every mother and child count. Geneva: World Health Organization. http://www.who.int/whr/2005/media_centre/facts_en.pdf (accessed July 2, 2007).

WHO Collaborative Study Team. 2000. Effect of breastfeeding on infant and child mortality due to infectious diseases in less developed countries: a pooled analysis. WHO Collaborative Study Team on the Role of Breastfeeding on the Prevention of Infant Mortality. Lancet 355 (9202): 451-5.

Winch, P. J., M. A. Alam, A. Akther, D. Afroz, and e. al. 2005. Local understandings of vulnerability and protection during the neonatal period in Sylhet district, Bangladesh: a qualitative study. Lancet 366 (9484): 478.

Xu, B., P. Rantakallio, M.-R. Jarvelin, and X. L. Fang. 1997. Sex differentials in perinatal mortality in China and Finland. Soc Biol 44 (3-4): 170.

Yan, R. Y. 1989. How Chinese clinicians contribute to the improvement of maternity care. Int J Gynaecol Obstet 30 (1): 23-6.

Yasmin, S., D. Osrin, E. Paul, and A. Costello. 2001. Neonatal mortality of low-birth-weight infants in Bangladesh. Bull World Health Organ 79 (7): 608.

Yu, V. Y. H. 2003. Global, regional and national perinatal and neonatal mortality. J Perinat Med 31 (5): 376-379.

Zhong-Cheng, L., J. K. Williams, W. Russell, M. L. Robert, M. Jemal, and M. S. Kramer. 2004. Disparities in Birth Outcomes by Neighborhood Income: Temporal Trends in Rural and Urban Areas, British Columbia. Epidemiol 15 (5): 679-686.

Zimicki, S., L. Nahar, A. M. Sarder, and S. DSouza. 1985. Demographic Surveillance System-Matlab:Cause of death reporting in Matlab; source book of cause-specific mortality rates 1975-81. Dhaka: International Centre for Diarrhoeal Disease Research, Bangladesh.

Zupan, J. 2005. Perinatal mortality in developing countries. N Engl J Med 352 (20): 2047-8.

'AQ 200__, Matlab　　　　PC No. | | | | |

Health and Demographic Surveillance System-Matlab
<u>ICDDR,B: Centre for Health and Population Research</u>

Verbal Autopsy Questionnaire
Part 1: Neonatal Deaths (0-28 days old)

সাক্ষাৎকার গ্রহনকারীর জন্য নির্দেশাবলী: মৃত শিশুর বাড়িটি চিহ্নিত করার পর বাড়ির/পরিবারের সদস্যদের সাথে কুশল বিনিময় এবং সমবেদনা জানানোর মধ্যমে নিজেকে তাদের মাঝে গ্রহনযোগ্য বরে তুলুন এবং তাদের নিকট আপনার পরিচয় ও কাজের উদ্দেশ্য ব্যাখ্যা করুন। তারপর নিম্নের উল্লেখিত যোগ্যতা অনুযায়ী প্রধান উত্তরদাতা নির্বাচন করুন। যদি প্রথমবার সম্ভব না হয় তবে সাক্ষাতের পরবর্তী সময় নির্ধারন করুন যখন মা অথবা প্রধান উত্তরদাতা বাড়িতে উপস্থিত থাকবেন।

যোগ্যতা:

- *যিনি মৃত শিশুর খুবই ঘনিষ্ট (বেশীর ভাগ ক্ষেত্রেই মা)*
- *শেষ অসুখের সময় উপস্থিত ছিলেন এবং*
- *রোগের উপসর্গ, লক্ষণ ও চিকিৎসা সম্পর্কে জানেন এবং ভালভাবে বলতে পারেন*

I. IDENTIFICATION OF THE RESPONDENT

1.1	সাক্ষাতের সময় যারা উপস্থিত আছেন, তাদের মধ্যে কারা শেষ অসুখের সময় উপস্থিত ছিলেন?				
	সাক্ষাৎকার গ্রহনের সময় উপস্থিত ব্যক্তির নাম:		মৃত শিশুর সাথে সম্পর্ক	অসুস্থকালীন উপস্থিত ছিলেন	
				হ্যাঁ	ন
	1			1	2
	2			1	2
	3			1	2
	(Code:1 = মা, 2 = বাবা, 3 = বোন, 4 = ভাই, 5 = দাদী/নানী, 6 = দাদা/নানা, 7 =চাচা/চাচী, 8 = অন্যান্য:)				
1.2	প্রধান উত্তরদাতার Line # : ☐		1.3. মৃত শিশুর সাথে তার সম্পর্ক কি? ☐		
1.4	প্রধান উত্তরদাতার বয়স (বছরে)ঃ		☐		
1.5	তিনি কত বৎসরের প্রাতিষ্ঠানিক শিক্ষা সম্পন্ন করেছেন? *(Code: 98 = কখনো যায়নি, 99 = অজানা)*		☐		
1.6	যদি মৃত শিশুর মা উপস্থিত না থাকেন, তিনি কি এখনও বেঁচে আছেন?		হ্যাঁ .... না .... অজানা .... প্রযোজ্য নয়	1 2 8 9	

II. BACKGROUND INFORMATION ABOUT THE INTERVIEWER

2.1	সাক্ষাৎকার গ্রহনকারীর নাম: ________________	কোড: ☐☐
2.2	সাক্ষাতের তারিখ (dd/mm/yy):	☐☐☐☐☐☐
2.3	প্রথমবার (Attempt) সাক্ষাতের তারিখ:	☐☐☐☐☐☐
2.4	২য় বার সাক্ষাত গ্রহনের তারিখ:	☐☐☐☐☐☐

III. IDENTIFICATION & DEMOGRAPHIC DATA OF THE DECEASED

3.1	শিশুর নাম: ____________	RID:	☐☐☐☐☐☐☐☐☐☐
3.2	মায়ের নাম: ____________	CID:	☐☐☐☐☐☐☐☐☐
3.3	পিতার নাম: ____________	CID:	☐☐☐☐☐☐☐☐☐
3.4	গ্রামের নাম: ____________	3.5 বাড়ির নাম: ____________	বাড়ি কোড: ☐☐☐
3.6	শিশুর জন্ম তারিখ (দিন-মাস-বছর):		☐☐☐☐☐☐
3.7	শিশুর মৃত্যু তারিখ (দিন-মাস-বছর)		☐☐☐☐☐☐
3.8	মৃত্যুকালে বয়স (দিন/ঘন্টা/মিনিট):		☐ দিন ☐ ঘন্টা ☐ মিনিট
3.9	শিশুর লিঙ্গ:		1 = পুরুষ	2 = মহিলা

IV BACKGROUND INFORMATION ON THE DEATH

OPEN HISTORY QUESTION:

4.1 মৃত্যুর আগের শিশুটির সর্বশেষ অসুস্থতা সম্পর্কে আপনি আমাকে দয়া করে কিছু বলবেন কি?

সাক্ষাৎকার গ্রহনকারীর জন্য নির্দেশাবলী: *উত্তরদাতাকে তার নিজের ভাষায় বলার জন্য সহায়তা করুন। উত্তরদাতার বলার পর, যতক্ষন পর্যন্ত না বলে যে আর কিছু বলার নেই, ততক্ষন পর্যন্ত জিজ্ঞাসা করতে থাকুন আরও কিছু ছিল কিনা। উত্তরদাতার স্বতস্ফুর্তভাবে বলা রোগের লক্ষণগুলো লিপিবদ্ধ করুন ও অপরিচিত কোন শব্দ থাকলে তার নীচে লাইন টেনে চিহ্নিত করুন।*

4.2	একটু সময় নিয়ে মৃত্যুর পূর্বে যে যে লক্ষণ বা আলামতগুলো ছিল সে গুলো ক্রমানুসারে লিপিবদ্ধ করুন।				
	লক্ষণ সমূহ		অসুস্থতার লক্ষণ শুরুর বয়স	লক্ষণের স্থায়িত্ব (দিন/ঘন্টা/মিনিট)	কতটা গুরুতর:(1= সামান্য, 2= মোটামুটি, 3= মারাত্মক)
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	যখনই সম্ভব, লক্ষণগুলির জন্য স্থানীয় ভাষা ব্যবহার করুন।				

V. দুর্ঘটনা এবং আঘাত (ACCIDENTS/INJURIES)

5.1	সে কি কোন আঘাত বা দূর্ঘটনায় মারা গিয়েছিল?	হ্যাঁ . . . . 1 না . . . . 2 অজানা. 9			2, 9 → 6.1
5.1.1	কি ধরনের দুর্ঘটনা বা আঘাত? উত্তরদাতাকে নিজ থেকে বলতে দিন।		হ্যাঁ	না	
	কুকুর/জন্তুর কামড়		1	9	
	সাপের কামড়		1	9	
		অন্যের দ্বারা	দুর্ঘটনা জনিত	না	
	ট্রেন/রোড এক্সিডেন্ট	2	3	9	
	নৌকায়/লঞ্চ এক্সিডেন্ট	2	3	9	
	পানিতে ডুবে	2	3	9	
	পড়ে গিয়ে	2	3	9	
	কেটে গিয়ে	2	3	9	
	শ্বাসরুদ্ধ করে (ফাঁসি)	2	3	9	
	বিষ প্রয়োগ করে (specify)	2	3	9	
	এসিডদগ্ধ হয়ে	2	3	9	
	অগ্নিদগ্ধ হয়ে		3	9	
	খৎনা করার সময়	2	3	9	
	অন্যান্য (উল্লেখ করুন)......................	2	3	9	
5.1.2	সে কি দুর্ঘটনা বা আঘাত প্রাপ্তিস্থলে মারা গিয়েছিল?	হ্যাঁ . . . . 1 না . . . . 2 অজানা. 9			1 → 8.3
5.1.3	আঘাত প্রাপ্তি বা দুর্ঘটনার পর কতক্ষণ শিশুটি বেচেঁছিল? *(Code: 99 = অজানা)*	[ ][ ] দিন ঘন্টা			

5.1.4	শিশুটি কি মৃত্যুর আগে চিকিৎসা পেয়েছিল?	হ্যাঁ . . . . 1 না . . . . 2 অজানা 9	
	Note: Skip to Q.8.3 in MEDICAL CONSULTATION		

VI. SYMPTOMS CONCERNING MOTHER & NEONATE

6.1	মায়ের নিম্মের অসুস্থতাগুলোর কোনটি ছিল কিনা জিজ্ঞাসা করুন: (একাধিক উত্তর হতে পারে)	হ্যাঁ	না	অজানা	
	উচ্চ রক্তচাপ (Hypertension)	1	2	9	
	হৃদ রোগ (Heart diseases)	1	2	9	
	ডায়াবেটিস (Diabetes)	1	2	9	
	যক্ষা (TB)	1	2	9	
	অন্যান্য রোগ (উল্লেখ করুন)	1	2	9	
	EVENTS CONCERNING PREGNANCY AND DELIVERY				
6.2	তিনি (মা) কতমাস যাবৎ গর্ভবতী ছিলেন? *(Code: 99 = অজানা)*	মাস			
6.3	মায়ের সর্বশেষ গর্ভাবস্থায় বা প্রসবে মায়ের কি কি জটিলতা হয়েছিল?	হ্যাঁ	না	অজানা	
	1. মায়ের খিঁচুনী ছিল (Convulsions)	1	2	9	
	2. রক্তপাত (Antenatal bleeding)	1	2	9	
	3. প্রসবপূর্ব বাচ্চার নড়াচড়া বন্ধ/কমে যাওয়া	1	2	9	
	4. গর্ভাবস্থায় জ্বর (Fever/Febrile illness during pregnancy)	1	2	9	
	5. প্রসবকালীন অতিরিক্ত রক্তপাত (Excessive bleeding)	1	2	9	
	6. প্রসব ব্যথা শুরুর ১ দিন বা তার আগে পানি ভাঙ্গা	1	2	9	
	7.পানি ভাঙ্গা-পানি বাদামী/সবুজ/হলুদ রংয়ের/দুর্গন্ধযুক্ত	1	2	9	
	8. কষ্টদায়ক প্রসব	1	2	9	
	9. দীর্ঘায়িত/কষ্টদায়ক প্রসব (১২ ঘন্টা +)	1	2	9	
	10. উল্টা প্রসব (Breech)	1	2	9	
	11. নাড়ী (Umbilical cord) আগে আসা (প্রসব কালে)	1	2	9	
	12. নাড়ী শিশুর গলায় পেচাঁনো	1	2	9	
	13. পা ফোলা/মুখ ফোলা	1	2	9	
	14. জন্ডিস	1	2	9	
	15. অন্যান্য (উল্লেখ করুন).	1	2	9	

			হ্যাঁ	না	অজানা	
6.4	শিশুটি কি ভাবে ভূমিষ্ট হয়েছিল? (একটি উত্তর হবে)		হ্যাঁ	না	অজানা	
		নরমাল ডেলিভারী(Vaginal)	1	2	9	
		স্যালাইন ও ঔষধ প্রয়োগে (Vaginal)	1	2	9	
		ইপিসিওটমি (Normal)	1	2	9	
		স্যালাইন+ঔষধ+ইপিসিওটমি	1	2	9	
		ফরসেপ (যন্ত্র দিয়ে)	1	2	9	
		পেট কেটে (সিজারিয়ান)	1	2	9	
		অন্যান্য	1	2	9	
		অজানা	1	2	9	

6.5	তার ডেলিভারী কোথায় হয়েছিল?	বাড়ি . . . . 1 ICDDR,B Sub Centre . . . . 2 ICDDR,B Hospital . . . . 3 উপজেলা স্বাস্থ্য কেন্দ্র . . . . 4 HFWC . . . . 5 প্রাইভেট হাসপাতাল/ক্লিনিক . . . . 6 জেলা সরকারী হাসপাতাল বা তদুর্ধ . . . . 7 মাতৃসদন (MCWC) . . . . 8 পথিমধ্যে . . . . 9 অন্যান্য (উল্লেখ করুন) 10	
6.5.1	যদি কোন স্বাস্থ্যসেবা প্রতিষ্ঠানে ডেলিভারী হয়ে থাকে তা হলে তার নাম ও ঠিকানা লিখুন: ____________________ ______________________________ ☐		

			হ্যাঁ	না	অজানা	
6.5.2	যদি প্রসবকার্য বাড়ীতে হয়ে থাকে তাহলে প্রধানত কে কে জড়িত ছিল? (একাধিক উত্তর)		হ্যাঁ	না	অজানা	
		ডাক্তার	1	2	9	
		নার্স/MW/LFPV/FWV	1	2	9	
		টিবিএ (Trained)	1	2	9	
		টিবিএ (Untrained)	1	2	9	
		আত্মীয়/প্রতিবেশী	1	2	9	
		গ্রাম ডাক্তার/পল্লী চিকিৎসক	1	2	9	
		কবিরাজ/হাকীম/হোমিওপ্যাথ	1	2	9	
		নিজে	1	2	9	
		অন্যান্য (উল্লেখ করুন).	1	2	9	

EVENTS CONCERNING NEONATE

6.6	শিশুটি কি একক বা জমজ জন্মে ছিল?	একক . . . . 1 জমজ . . . . 2 দুইয়ের অধিক. 3	

6.7	জন্মের পর বাচ্চাটির গায়ে কি থেঁতলানো বা আঘাতের চিহ্ন ছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
6.8	জন্মের সময় বাচ্চাটির কি কোন অঙ্গ বিকৃতি ছিল? (যেমন- ঠোঁট কাটা, পা বাঁকা)	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 6.9
6.8.1	সংক্ষেপে বর্ননা দিন: ______________________	☐☐	
6.9.	জন্ম ওজন (কেজিতে) 72 ঘন্টার মধ্যে: *Code: 98 = ওজন নেয়নি, 99 = অজানা)*	☐ কেজি	
6.10.	জন্মের সময় শিশুটির আকার কিরূপ ছিল? *(পড়ে শুনান)*	খুব ছোট .... 1 স্বাভাবিকের চেয়ে ছোট .... 2 স্বাভাবিক .... 3 স্বাভাবিকের চেয়ে বড় 4	
6.11	জন্মের পর শিশুটি কি স্বাভাবিক শ্বাস নিচ্ছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
6.12	জন্মের পর সে কি আপনা আপনি কাঁদতে পেরেছিল? (সামান্য চেষ্টা করে কাদাঁনো)	হ্যাঁ .... 1 না .... 2 অজানা 9	
6.13	জন্মের কতক্ষন (মিনিট) পরে কেঁদেছিল? *(Code: 99 = অজানা)*	☐☐	

VII. LEADING QUESTIONS ON SYMPTOMS & SIGNS OF FINAL ILLNESS

7.1	মৃত্যুর আগে শিশুটি কতদিন/ঘন্টা যাবৎ অসুস্থ ছিল? *(Code: 99 = অজানা)*	☐ দিন ☐ ঘন্টা	
7.2	শেষ অসুস্থতার সময় তার কি খিঁচুনী ছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.3
7.2.1	খিঁচুনীর সময় শরীর ধনুকের মত বাঁকা হয়ে যেত?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.3
7.2.2	জন্মের কতদিন পর খিঁচুনী শুরু হয়েছিল? *(Code: 99 = অজানা)*	☐ দিন	

7.3	সর্বশেষ অসুস্থতার সময় শিশুটি কি অজ্ঞান হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.4	শেষ অসুস্থতার সময় তার মাথার চাঁদি কি ফুলেছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.5	সর্বশেষ অসুস্থতার সময় শিশুটির কি কাঁশি ছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.6
7.5.1	(যদি হ্যাঁ হয়) জন্মের কতদিন পর থেকে কাঁশি ছিল? *(Code: 99 = অজানা)*	☐☐	
7.6	সর্বশেষ অসুস্থতার সময় শিশুটি কি ঘন ঘন শ্বাস ফেলত?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.7
7.6.1	জন্মের কতদিন/ঘন্টা পর ঘন ঘন শ্বাস ফেলতো? *(Code: 99 = অজানা)*	☐ দিন ☐ ঘন্টা	
7.7	সর্বশেষ অসুস্থতার সময় তার কি শ্বাসকষ্ট হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.8
7.7.1	জন্মের কতদিন/ঘন্টা পর তার শ্বাসকষ্ট শুরু হয়েছিল? *(Code: 99 = অজানা)*	☐ দিন ☐ ঘন্টা	
7.8	সর্বশেষ অসুস্থতার সময় শ্বাস ফেলতে বুকের খাচাঁ বেশী ডেবে যেত? (severe chest indrawing)	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.9	শ্বাস-প্রশ্বাসের সময় তার অস্বাভাবিক শব্দ হতো কি?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.10.	কখনো শিশুটির ক্ষনিকের জন্য শ্বাস থেমে থেমে আবার কি শ্বাস চালু হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.11	শেষ অসুস্থতার সময় তার কি জ্বর ছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.12

7.11.1	জন্মের কতদিন পর জ্বর শুরু হয়েছিল? *(Code: 99 = অজানা)*	[ ] দিন	
7.11.2	কতদিন জ্বর স্থায়ী হয়েছিল? *(Code: 99 = অজানা)*	[ ] দিন	
7.12.	শেষ অসুস্থতার সময় বাচ্চার শরীরে হাত দিলে শরীর কি ঠান্ডা মনে হতো?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.13
7.12.1	মৃত্যুর কতদিন/ঘন্টা আগে থেকে শরীর ঠান্ডা ছিল? *(Code: 99 = অজানা)*	[ ] দিন [ ] ঘন্টা	
7.13	শেষ অসুখের সময় শিশুটির কি হাত পা নড়াচড়া বন্ধ বা কমে গিয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.14
7.13.1	মৃত্যুর কতদিন/ঘন্টা আগে থেকে হাত পা নড়া বন্ধ বা কমে গিয়েছিল? *(Code: 99 = অজানা)*	[ ] দিন [ ] ঘন্টা	
7.14	শিশুটির কান থেকে কি পুঁজ বের হতো?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.15	সে কি কাঁদা বন্ধ করে দিয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.16
7.15.1	জন্মের কতদিন পর কাঁদা বন্ধ করে দিয়েছিল? *(Code: 99 = অজানা)*	[ ]	
7.16	জন্মের পর শিশুটি কি স্বাভাবিকভাবে বুকের দুধ/বোতলের দুধ পান বন্ধ করে দিয়েছিলে?	হ্যাঁ .... 1 না .... 2 প্রযোজ্য নয় .... 8 অজানা 9	2, 8, 9 → 7.17
7.16.1	জন্মের কতদিন পর শিশুটি দুধ পান বন্ধ করে দিয়েছিল? *(Code: 99 = অজানা)*	[ ]	
7.17	শেষ অসুস্থতার সময় কি তার চোখ বা চামড়া হলুদ বর্নের হয়ে গিয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.18
7.17.1	জন্মের কতদিন পর তার চোখ বা চামড়া হলদে হয়ে গিয়েছিল? *(Code: 99 = অজানা)*	[ ]	

7.18.	শেষ অসুস্থতার সময় কি তার নাভী লাল হয়েছিল বা নাভী দিয়ে পূঁজ পড়ত?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.19	শেষ অসুস্থতার সময় কি চামড়ায় ফোসকা বা পুঁজভর্তি গোটা হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.20.	শেষ অসুস্থতার সময় তার শরীরের কোন স্থান হতে রক্ত-পাত হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.21
7.20.1	কোথা থেকে? (একাধিক উত্তর হতে পারে)	মুখ .... 1 নাক .... 2 নাভী .... 3 পায়ুপথ .... 4 অন্যান্য... .... 5 অজানা 9	
7.21	সর্বশেষ অসুস্থতার সময় তার কি ডায়রিয়া (ঘন ঘন পাতলা পায়খানা) হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.22
7.21.1	ডায়রিয়া কতদিন স্থায়ী হয়েছিল? *(Code: 99 = অজানা)*	☐ দিন	
7.21.2	পায়খানার সাথে রক্ত যেত কি?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.22.	শেষ অসুস্থতার সময় তার কি বমি হয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	
7.23	সর্বশেষ অসুস্থতার সময় তার কি পেট ফেঁপে/ফুলে গিয়েছিল?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 7.24
7.23.1	কতদিন/ঘন্টা ধরে এই ফাঁপা/ফোলা ছিল? *(Code: 99 = অজানা)*	☐ দিন ☐ ঘন্টা	
7.24	মৃত্যুর আগে শিশুটির শরীরে কোন অপারেশন করা হয়েছিল	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 8.1
7.24.1	মৃত্যুর কতদিন আগে শিশুটির শরীরে অপারেশন করা হয়েছিল? *(Code: 99 = অজানা)*	☐	
7.24.2	শরীরের কোন স্থানে অপারেশন করা হয়েছিল?	☐	

VIII. MEDICAL CONSULTATIONS

8.1	যে অসুস্থতার জন্য শিশুটি মারা গিয়েছিল, সে অসুখের কোন চিকিৎসা হয়েছিল কি?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 8.3
8.1.1	শিশুটির মৃত্যুকালীন অসুস্থতার সময় কে কে তার চিকিৎসা করেছিলেন? *নির্দেশাবলী: উত্তরদাতার উত্তর দেওয়া শেষ হওয়ার সাথে সাথে জিজ্ঞাসা করুন: আর কোথাও থেকে চিকিৎসা নিয়েছিল কি?* জিজ্ঞাসা করতে থাকুন, যতক্ষন না পর্যন্ত উত্তরদাতা বলেন যে, আর কোথাও থেকে চিকিৎসা নেয়নি।		
	a. 1st Provider ☐ b. 2nd Provider ☐ c. 3rd Provider ☐ c. 4th/last Provider ☐ *Code: 1 = গ্রাম/পল্লী চিকিৎসক, 2 = ফার্মেসী/ঔষধবিক্রেতা, 3 = হোমিওপ্যাথ, 4 = স্বাস্থ্য কেন্দ্র* *5 = এমবি বিএস/বিশেষজ্ঞ চিকিৎসক (Specialist), 6 = SACMO/MA, 7 = নার্স/মিডওয়াইফ/এলএফপিভি/FWV* *8 = কবিরাজ/হেকিম, 9 = আধ্যাত্মিক চিকিৎসক/ঈমাম, 10 = পরিবারের সদস্য/আত্মীয়, 11 = অন্যান্য (উল্লেখ করুন)*		
8.1.2	সর্বশেষ অসুখের সময় আপনি শিশুটিকে কোথায় চিকিৎসার জন্য নিয়েছিলেন? (একাধিক উত্তর হতে পারে)	**সরকারী প্রতিষ্ঠান সমূহ:** সরকারী হাসপাতাল (DH & Above) ... 1 MCWC .... 2 উপজেলা স্বাস্থ্য কমপ্লেক্স .... 3 HFWC/RD/SC/CC .... 4 **এনজিও প্রতিষ্ঠান সমূহ:** ICDDR,B হাসপাতাল .... 5 ICDDR,B সাব-সেন্টার .... 6 এনজিও হাসপাতাল .... 7 এনজিও ক্লিনিক .... 8 **প্রাইভেট (ব্যক্তিগত) প্রতিষ্ঠান সমূহ:** হাসপাতাল/ক্লিনিক/প্রাইভেট চেম্বার .... 9 অন্যান্য (উল্লেখ করুন) .... 10 কোথাও নেয়নি 11	
8.2	মৃত্যুর আগে শিশুটিকে হাসপাতালে/ক্লিনিকে ভর্তি করা হয়েছিল কি?	হ্যাঁ .... 1 না .... 2 অজানা 9	2, 9 → 8.3

8.2.1	হাসপাতালে ভর্তির তালিকা লিখুন: *(অতি সাম্প্রতিক থেকে শুরু করুন)*	Date of admission			
	স্বাস্থ্য সেবা প্রতিষ্ঠানের নাম	দিন	মাস	বছর	হাসপাতালে ভর্তির কারণ সমূহ
	1 2 3 4				

8.3	মৃত্যুর স্থান ঃ	বাড়ীতে	1	→ 8.3.1
		স্বাস্থ্য সেবা প্রতিষ্ঠানে	2	→ 8.3.2
		পথিমধ্যে	3	→ 8.5
		দুর্ঘটনা স্থলে	4	→ 8.5
		অন্যান্য: (উল্লেখ করুন)	5	→ 8.5
8.3.1	যদি বাড়ীতে মারা গিয়ে থাকে তা হলে ব্লক নাম ও কোড নাম্বার লিখুনঃ গ্রাম নাম: ____________ ব্লক নাম: ____________ ব্লক কোড: [ ]			→ 8.5
8.3.2	যদি শিশুটি কোন স্বাস্থ্যসেবা প্রতিষ্ঠানে মারা যায় তা হলে, উহার নাম ও ঠিকানা লিখুন: *(Code: Q.8.1.2 অনুসারে লিখুন)* ____________ ____________ [ ]			
8.4	হাসপাতাল থেকে কেউ কি আপনাকে মৃত্যুর কারণটি বলেছিল?	হ্যাঁ	1	
		না	2	→ 8.5
		অজানা	9	→ 8.5
8.4.1	কে কারনটি বলেছিল?	সেবিকা	1	
		ডাক্তার	2	
		অন্যান্য (উল্লেখ করুন)	3	
8.4.2	তিনি মৃত্যুর কি কারণ বলেছিলেন? (কারণ সমূহ লিখুন) I. ____________ II. ____________			
8.5	কি কারণে শিশুটির মৃত্যু হয়েছিল বলে আপনি মনে করেন? (কারণ সমূহ লিখুন) I. ____________ II. ____________			

IX. স্বাস্থ্য তথ্য (HEALTH RECORDS)

9.1	শিশুটির কোন স্বাস্থ্য তথ্য আছে কি?	হ্যাঁ .... না .... অজানা	1 2 9	2, 9 → 9.3
9.2	আমি স্বাস্থ্য তথ্যখানা দেখতে পারি কি?	হ্যাঁ .... না .... অজানা	1 2 9	

তথ্যখানা থেকে Symptoms, Diagnosis and Treatment লিখুনঃ (সংযুক্ত করুন)

____

____

____

____

____

____

____

____

____

____

____

____

____

____

9.3	শিশুটির মৃত্যু প্রত্যায়ন পত্র আছে কি? (Death Certificate)	হ্যাঁ .... না .... অজানা	1 2 9	
9.4	আপনি (Interviewer) কি মৃত্যু প্রত্যায়ন পত্র দেখতে পেয়েছিলেন? *(এই প্রশ্নটি উত্তরদাতাকে জিজ্ঞেস করবেন না)*	হ্যাঁ .... না .... অজানা	1 2 9	
9.5	প্রত্যায়ন পত্র থেকে মৃত্যুর কারন লিপিবদ্ধ করুন: a. ______________________ কোড: [ ] ______________________ b. ______________________ কোড: [ ] ______________________			

উত্তরদাতাকে সহযোগিতার জন্য ধন্যবাদ জানান।

X. সাক্ষাৎকার গ্রহনকারীর মন্তব্য এবং পর্যবেক্ষন (মৃত্যুর কারণ সম্পর্কে সন্দেহ থাকলে তাও লিখুন):

____

____

____

____

____

____

Date of editing questionnaire | | | | | | | ***By Supervisor:*** | | |

For Office Use

Immediate Cause of Death: __________________ ***Diagnosed by:*** | *1.MA* | *2.MO* |

Underlying Cause of Death: __________________ ***Diagnosed by:*** | *1.MA* | *2.MO* |

If diagnosis is based purely on descriptions of morbidities, ICD-10 code be preceeded by 1. Otherwise it be preceeded by 2.

ICD-10 Code for Immediate Cause of Death: [ ] ***Assigned by:*** | *1.MA* | *2.MO* |

ICD-10 Code for Underlying Cause of Death: [ ] ***Assigned by:*** | *1.MA* | *2.MO* |

ICDDR,B HDSS VAQ- Matlab Pc. No. [| | |]

VERBAL AUTOPSY QUESTIONNAIRE
Part 1: NEONATAL DEATHS (0 - 28 days)

***Instructions to interviewers** : Introduce yourself and explain the purpose of your visit to the main respondent and others present during visit. The main respondent must be:*

- *Closely related to the deceased baby, usually mother*
- *Present during the illness that led to death and*
- *Able to describe illness symptoms and medical consultations prior to death*

Seek his/her consent for asking questions concerning symptoms that the deceased had/showed when s/he was ill. During interview, help can also be taken from other persons present. If you could not interview in present visit, arrange a time to revisit the household when the main respondent will be at home.

I IDENTIFICATION OF THE RESPONDENT

1.1 List the names of persons present during interview and during the illness that led to death?

Name of those present in the interview	Their relationships to the deceased	Present during illness: Yes	Present during illness: No
		1	2
		1	2
		1	2

(Code: 1=Mother, 2=Father, 3=Sister, 4=Brother, 5=Grand mother, 6=Grand father, 7=Aunt/uncle, 8=Other.......)

1.2 Line number of the main respondent**:** [ ] **1.3** His/her relationship to the deceased: [ ]

1.4 His/her age (in years): [ ] **1.5** His/her completed years of education: [ ]

(Code: 99=NK)

1.6 If mother of the deceased baby is not present at the interview, is mother still alive? 1.Yes 2. No

II BACKGROUND INFORMATION ABOUT THE INTERVIEWER

2.1 Interviewer's name: ____________________ Code: [ ]

2.2 Date of interview (dd/mm/yy): [| | | | |]

2.3 Date of first interview attempted: [| | | | |]

2.4 Date arranged for second interview: [| | | | |]

III IDENTIFICATION & DEMOGRAPHIC DATA OF THE DECEASED

3.1 Name of the deceased:____________________ RID: [| | | | | | | | | |]

3.2 Mother's name: ____________________ CID: [| | | | | | | | |]

3.3 Father's name: ____________________ CID: [| | | | | | | | |]

3.4 Village name: ______________ **3.5** Bari name: ______________ Code: [| |]

3.6 Date of birth (dd/mm/yy): | | | | | | | **3.7** Date of death: | | | | | | |

3.8 Age at death (in days): | | **3.9** Sex of the deceased: | 1. Male | 2. Female |

IV BACKGROUND INFORMATION ON THE DEATH

OPEN HISTORY QUESTION:

4.1 Could you tell me about the illness/events that led to her/his death?
Prompt: Was there anything else?

Instructions to interviewers - Allow the respondent to tell you about the illness in his or her own words. Do not prompt except for asking whether there was anything else after the respondent finishes. Keep prompting until the respondent says that there was nothing else. Take a moment to write all symptoms mentioned spontaneously in the open history question. While recording, underline any unfamiliar terms.

blank page

4.2 Summary of symptoms and signs reported by the respondents:

Symptoms	Symptoms started on which day of life	Duration of symptoms (in days)	Severity: 1= mild, 2= moderate, 3=severe
1			
2			
3			
4			
5			

Note: When possible, use local term for the symptom.

V ACCIDENTS/INJURIES

5.1 Did the baby die from an accident or injury? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 6.1)

5.1.1 What was the kind of injury or accident? Allow the respondent to answer spontaneously?

Kind of injury or accident		**Yes**	**No**
Animal bite		1	9
Snake bite		1	9
	Non-self	**Accident**	**No**
Train/road accident	2	3	9
Boat/launch accident	2	3	9
Drowning	2	3	9
Fall	2	3	9
Cut	2	3	9
Suffocation by pressing neck	2	3	9
Poison (specify)	2	3	9
Acid burn	2	3	9
Burn	2	3	9
Circumcision	2	3	9
Other (specify)	2	3	9

5.1.2 Did the baby die at the site where accident or injury occurred? | 1. Yes | 2. No | 9. NK |
(If Yes, skip to Q 8.3 in ***MEDICAL CONSULTATIONS*** *)*

5.1.3 For how long (days) after the accident or injury did the baby survive *(Code: 99=NK)* ? [ ]

5.1.4 Did the baby receive medical care before death? | 1. Yes | 2. No | 9. NK |

Note: *In case of death from accident or injury, skip to Q 8.3 in* ***MEDICAL CONSULTATIONS)***

VI SYMPTOMS CONCERNING MOTHER AND NEONATE

6.1 Did the mother have any of the following illnesses or symptoms?

	Yes	No	NK
Hypertension	1	2	9
Heart disease	1	2	9
Diabetes	1	2	9
TB	1	2	9
Others (specify)	1	2	9

EVENTS CONCERNING PREGNANCY AND DELIVERY:

6.2 How many months long was the pregnancy *(Code: 9=NK)* ? [ ]

6.3 Did the mother have any of the following complications during her last pregnancy, labour or delivery (record all responses)? Keep probing:

	Yes	No	NK
1. Convulsions	1	2	9
2. Antenatal bleeding	1	2	9
3. Baby stopped/reduced playing in the womb before labour	1	2	9
4. Febrile illness during pregnancy	1	2	9
5. Excessive bleeding during delivery	1	2	9
6. Water broke 1 or more days before labour	1	2	9
7. Difficult labour	1	2	9
8. Prolonged labour (12 hours +)	1	2	9
	Yes	No	NK
9. Baby delivered feet first	1	2	9
10. Umbilical cord came out before delivery of baby	1	2	9
11. Umbilical cord circled around the neck of baby	1	2	9
12. Oedematous swelling in legs	1	2	9
13. Jaundice	1	2	9
14. Other (specify)	1	2	9

6.4 How was the baby delivered?

1. Normal vaginal delivery	2. Vaginal delivery by use of saline & drug
3. Vaginal delivery with Episiotomy	4.Vaginal delivery by use of saline, drug & Episiotomy
5. Using instrument (ventose/forcep)	
6. Caesarean	9. NK

6.5 Where was the baby delivered?

1. Home	2. ICDDR,B sub-centre
3. ICDDR,B hospital	4. Upazila health complex
5. HFWC	6. Private clinic/hospital
7. Govt. hospital (district level and above)	8. MCWC
9. In-transit	10. Other (specify)

6.5.1 If delivered in a health facility, write its name and address: ____________________

6.5.2 If delivered at home, who were involved in conducting delivery (multiple responses possible)?

1. Doctor (MBBS)	2. Nurse/Midwife/LFPV/FWV
3. Trained TBA	4. Untrained TBA
5. Relative/neighbour	6. Village doctor/palli chikitshok
7. Kabiraj/hakim/homeopath	8. Religious/spiritual healer
9. Self	10. Other (specify)

EVENTS CONCERNING NEONATE:

6.6 Was the baby a singleton or multiple birth? | 1.Singleton | 2. Twin | 3. Multiple |

6.7 Were there any bruises or signs of injury on baby's body after the birth? | 1. Yes | 2. No | 9. NK |

6.8 Did the baby have any malformations at birth? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 6.9)

6.8.1 Describe malformations: ______

6.9 Weight (kg) within 72 hours of birth: *(Code: 98=not measured, 99=NK)*

6.10 At the time of birth what was the size of the baby?

1. Very small	2. Smaller than average
3. About average	4. Larger than average

6.11 Was the baby able to breathe after delivery? | 1. Yes | 2. No | 9. NK |
(Note: This does not include gasps or very brief efforts to breathe)

6.12 Was the baby able to cry after birth? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.1)

6.13 If Yes, how long after birth (in minutes)?

VII LEADING QUESTIONS TO ELICIT SYMPTOMS & SIGNS OF THE FINAL ILLNESS THAT LED TO DEATH

7.1 For how long (days) was the baby ill before s/he died? *(Code: 99=NK)*

7.2 During the last illness, did s/he have spasms or convulsions? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.3)

7.2.1 Was it a bow-like convulsion? | 1. Yes | 2. No | 9. NK |

7.2.2 How many days after the birth, did the baby develop convulsion? *(Code: 99=NK)*

7.3 During the illness that led to death, did s/he become unconscious? | 1. Yes | 2. No | 9. NK |

7.4 During the last illness, did s/he have bulging fontanelle? | 1. Yes | 2. No | 9. NK |

7.5 During the illness that led to death, did the baby have a cough? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.6)

7.5.1 How many days after birth, the baby had cough? *(Code: 99=NK)*

7.6 During the last illness, did the baby have fast breathing? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.7)

7.6.1 How many days after birth did the baby have fast breathing? *(Code: 99=NK)*

7.7 During the last illness, did s/he have difficulty in breathing? | 1. Yes | 2. No | 9. NK |

(If answer is 2 or 9, skip to Q 7.8)

7.7.1 How many days after birth did the baby have difficulty in breathing? *(Code: 99=NK)* [ ]

7.8 During the last illness, did s/he have severe indrawing of chest? | 1. Yes | 2. No | 9. NK |

7.9 During the last illness, did s/he have grunting during respiration? | 1. Yes | 2. No | 9. NK |

7.10 During the last illness, did the baby ever have short period of stopping and restarting breathing? | 1. Yes | 2. No | 9. NK |

7.11 During the illness that led to death, did s/he have fever? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.12)

7.11.1 How many days did the fever last? *(Code: 99=NK)* [ ]

7.12 During the last illness, did his/her body feel cold when touched? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.13)

7.12.1 How many days before died, did his/her body feel cold when touched? *(Code: 99=NK)* [ ]

7.13 During the last illness, did s/he stop/reduce movement of body parts? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.14)

7.13.1 How many days before died, did s/he stop/reduce movement of body parts? *(Code: 99=NK)* [ ]

7.14 Did the baby have pus draining from ear? | 1. Yes | 2. No | 9. NK |

7.15 Did the baby stop being able to cry? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.16)

7.15.1 How many days before death, did the baby stop crying? (Code: 99=NK) [ ]

7.16 Did the baby stop being able to suck in a normal way? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.17)

7.16.1 How many days after birth, did the baby stop suckling? (Code: 99=NK) [ ]

7.17 During the last illness, did s/he have yellow eyes or skin? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.18)

7.17.1 How many days after the birth, did the baby develop yellow discoloration? *(Code: 99=NK)* [ ]

7.18 During the last illness, did s/he have redness around or drainage from the umbilical cord stump? | 1. Yes | 2. No | 9. NK |

7.19 During the last illness, did s/he have skin rash with blisters containing pus? | 1. Yes | 2. No | 9. NK |

7.20 During the illness that led to death, did s/he bleed from anywhere? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.21)

7.20.1 From where: | 1. Mouth | 2. Nose | 3. Umbilicus | 4. Per rectum | 5. Others (specify |

7.21 During the last illness, did s/he have diarrhoea (more frequent/liquid stools than usual)?
(If answer is 2 or 9, skip to Q 7.22) | 1. Yes | 2. No | 9. NK |

7.21.1 How many days, did the diarrhoea last? *(Code: 99=NK)* [ ]

7.21.2 Was the blood visible in the stools? | 1. Yes | 2. No | 9. NK |

7.22 During the last illness, did s/he have any vomiting? | 1. Yes | 2. No | 9. NK |

7.23 During the last illness, did s/he have any abdominal distension? | 1. Yes | 2. No | 9. NK |
(If answer is 2 or 9, skip to Q 7.24)

7.23.1 How many days/hours did s/he have abdominal distension? (Code: 99=NK) [ ] Days [ ] Hours

7.24 Did the baby have any operation before death? | 1.Yes | 2. No | 9. NK |
(If the answer is 2 or 9, skip to Q 8.1)

7.24.1 How many days before death, did s/he have the last operation? *(Code: 99=NK)* [ ]

7.24.2 What was the site of the operation? ______________________ [ ]

VIII **MEDICAL CONSULTATIONS**

8.1 During the illness that led to death, was the baby treated at all? | 1.Yes | 2. No | 9. NK |
(If the answer is 2 or 9, skip to Q 9.1in ***HEALTH RECORDS*** *)*

8.1.1 Write chronologically type of treatment providers consulted:

a. 1st provider: [ ] **b**. 2nd provider: [ ] **c**. 3rd/last provider: [ ]

(Code: 1=Village doctor/palli chikitshok, 2=Pharmacist/drug seller, 3=Homeopath, 4=Health facility, 5=Private chamber of MBBS doctors, 6=Private chamber of SACMO/MA, 7=Private chamber of nurse/midwife/FWV, 8=Kabiraj/hekim, 9. Religious/spiritual healer, 10=Family member/relative, 11= Others (specify...)

8.1.2 If treatment received from health facilities, circled relevant health facilities (multiple responses possible)

	Code
Government Sector:	
Hospital (district level and above)	1
MCWC	2
Upazila Health Complex	3
HFWC/RD/SC/CC	4
NGO Sector:	
ICDDR,B hospital	5
ICDDR,B sub-centre	6
NGO hospital	7
NGO clinic	8
Private Sector:	
Hospital/clinic	9
Other (specify)	10

8.2 Was s/he admitted in the hospital before s/he died? | 1.Yes | 2. No | 9. NK |
(If the answer is 2 or 9, skip to Q 8.3)

8.2.1 Write his/her hospital admissions (starting from recent)

Name of health institute	Date of admission	Reasons for admission
1		
2		
3		

8.3 Place of death: | 1. Home | 2. Health facility | 3. In-transit | 4. Spot death | 5. Others |

8.3.1 If died at home, write village & block names and code: ______________ [ ]
(Skip to Q 8.4)

8.3.2 If s/he died in a health facility, write its name and address: ______________

8.3.3 Did anyone from the health facility told you the cause of death? | 1.Yes | 2. No | 9. NK |

(If the answer is 2 or 9, skip to Q 8.4)

8.3.4 Who told you the cause of death? | 1. Nurse | 2. Doctor | 3. Others (specify) |

8.3.5 What did s/he say, was the cause of death?

I. ______________________________

II. ______________________________

8.4 In your opinion, what were his/her causes of death?

I. ______________________________

II. ______________________________

IX **HEALTH RECORDS**

9.1 Is there any health record that belongs to the deceased? | 1.Yes | 2. No | 9. NK |

(If answer is 2 or 9, skip to Q 9.3)

9.2 Can I see the health record? | 1.Yes | 2. No | 9. NK |

(If respondent allows you to see the health record, transcribe all symptoms, diagnosis amd medications within the 12 months before s/he died)

____

____

9.3 Was a death certificate issued? | 1.Yes | 2. No | 9. NK |

9.4 (*Do not ask*) Was the death certificate seen by interviewer? | 1.Yes | 2. No |

9.5 Record cause of death appearing in the death certificate**:**

a. ______________________________ Code: [ ]

b. ______________________________ Code: [ ]

X **Interviewer's comments and observations:** ______________________________

____

____

____

____

Date of editing questionnaire: [| | | | |] By supervisor: [|]

For Office Use

a	Immediate Cause of Death:	______________	Diagnosed by:	1. MA / 2. MO
b	Underlying Cause of Death:	______________	Diagnosed by:	1. MA / 2. MO

Note: *If diagnosis is based purely on descriptions of morbidities, the 3-digit ICD-10 code be preceded by 1, otherwise it be preceded by 2.*

c	ICD-10 Code for Immediate Cause of Death:	☐☐☐☐	Assigned by:	1. MA / 2. MO
d	ICD-10 Code for Underlying Cause of Death:	☐☐☐☐	Assigned by:	1. MA / 2. MO

Appendix C

MINUTE

Curtin
UNIVERSITY OF TECHNOLOGY

To	Md. Hafizur Rahman Chowdhury
From	Mohammed Ali
Subject	Protocol Approval **CIH 012-2005**
Date	20 September 2005
Copy	Dr Jaya Earnest; Ms Sue Gillieatt

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL s.darley@curtin.edu.au

Thank you for your "Form C (A) Application for Approval of Research with Minimal Risk (Ethical Requirements)" for the project titled "CAUSES OF AND HEALTH CARE SEEKING IN RELATION TO EONATAL DEATHS IN RURAL BANGLADESH: THE USE OF VERBAL AUTOPSY.". On behalf of the Human Research Ethics Committee I am pleased to inform you that the project is approved.

Approval of this project is for a period of two years **20 September 2005** to **20 September 2007**.

If at any time during the two years changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately. The approval number for your project is **HR CIH 012-2005**. *Please quote this number in any future correspondence.*

Please find attached your protocol details together with the application form/cover sheet.

Kind regards

Md. Ali

Mohammed Ali

ecturer, Centre for International Health and
Reviewer, Human Research Ethics Form C

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved by the Curtin University Human Research Ethics Committee. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784.

International Centre for Diarrhoeal Disease Research, Bangladesh
CENTRE FOR HEALTH AND POPULATION RESEARCH
Mail : ICDDR,B, GPO Box 128, Dhaka-1000, Bangladesh
Phone: 880-2-8811751-60, Telex : 642486 ICDD BJ
Fax : 880-2-8823116, 8812530, 8811568, 8826050, 9885657, 8811686, 8812529
Cable : Cholera Dhaka

Memorandum

28 November 2005

To : Dr. Hd. Hafizur Rahman Chowdhury
Principal Investigator of research protocol # 2005-041
Public Health Sciences Division (PHSD)

From: Prof. Alejando Cravioto
Chairman
Research Review Committee (RRC)

Sub : Approval of research protocol # 2005-041

Thank you for your research protocol # 2005-041 titled **"Causes of and Health Care Seeking in Relations to Neonatal Deaths in Rural Bangladesh: The Use of Verbal Autopsy"**. I have the pleasure to inform you that upon your satisfactory addressing of the issues raised by the reviewer, the protocol is hereby approved and you may proceed for obtaining approval of the ERC.

Terms of approval

The research protocol is approved as submitted for 31-month period from the date of starting the activities of the protocol. You should, therefore, notify the Committee Coordination Secretariat of the start date of the protocol.

This approval is only valid whilst you hold a position at ICDDR,B; and in the event of your departure from the Centre, a new Principal Investigator will be designated for the research protocol.

This approval shall remain valid for starting the protocol for a period up to 2 years from the date of the approval of the ERC, after two years, you shall have to seek approval (revalidation) of the RRC/ERC before starting the protocol. The RRC/ERC approval shall automatically deemed to be revoked after three years if the protocol is not started.

Any changes to the research protocol require the submission and approval of an amendment/addendum. Substantial variations may require a new protocol.

Continued approval of this protocol is dependent on your periodically updating the Centre's database for the protocol to show the progress; and a final report/completion report should be submitted at the conclusion of the protocol.

You shall submit a report for time extension of the protocol (in prescribed form) if you are unable to complete the protocol activities within the time mentioned in the protocol.

The RRC should be notified if the project is discontinued before the expected date of completion. The report form is available at the Committee Coordination Secretariat and on the Centre's Intranet.

You shall not use the data for any other purposes; and the ownership of data after certain period shall be determined as per Centre's rules and regulations.

I wish you all the success in conducting the research protocol.

Copy: Director, PHSD

International Centre for Diarrhoeal Disease Research, Bangladesh
CENTRE FOR HEALTH AND POPULATION RESEARCH
Mail : ICDDR,B, GPO Box 128, Dhaka-1000, Bangladesh
Phone: 880-2-8811751-60, Telex : 642486 ICDD BJ
Fax : 880-2-8823116, 8812530, 8811568, 8826050, 9885657, 8811686, 8812529
Cable : Cholera Dhaka

Memorandum

11 December 2005

To : Dr. Md. Hafizur Rahman Chowdhury
Principal Investigator of research protocol # 2005-041
Public Health Sciences Division (PHSD)
(Now on special leave for study at the Doctoral Programme
Curtin University, Australia)

From: Professor AKM Nurul Anwar
Chairman
Ethical Review Committee (ERC)

Sub : Approval of research protocol # 2005-041

Thank you for your memo dated December 7, 2005 and the modified version of your research # 2005-041 titled **"Causes of and Health Care Seeking in Relation to Neonatal Deaths in Rural Bangladesh: The Use of Verbal Autopsy".** Upon satisfactory addressing of the issues, excepting about the protocol title, raised by the reviewer on your research protocol, approval is hereby accorded. You should, however, make an attempt to obtain approval of the Doctoral Thesis Committee of the Curtin University, Australia, for modifying the title of the protocol as suggested by the primary reviewer.

You would be required to observe the following terms and conditions in implementing the research protocol:

As the Principal Investigator, the ultimate responsibility for scientific, and ethical conduct including the protection of the rights and welfare of study participants vest upon you. You shall also be responsible for ensuring the competence, integrity and ethical conduct of the investigators and other staff directly involved in this research protocol.

You shall conduct the study in accordance with the ERC-approved protocol and shall fully comply with any subsequent determinations by the ERC.

You shall obtain prior approval from the Research Review Committee and the ERC for any modification in the approved research protocol and/or approved consent form(s), except in case of emergency to safeguard/eliminate apparent immediate hazards to study participants. Such changes must be immediately reported to the ERC Chairman.

Data/samples to be received for your research protocol should not be disclosed, made available or use for purposes other than those specified in the protocol, and shall be preserved for a period, as specified under Centre's policies/practices.

You shall promptly and fully comply with the decision of the ERC to suspend or withdraw its approval for the research protocol.

You shall report progress of research to the ERC for continuing review of the implementation of the research protocol as stipulated in the ERC Guidelines. Relevant excerpt of ERC Guidelines and '*Annual/Completion Report for Research Protocol involving Human Subjects*' are attached for your information and guidance.

I wish you success in running the above-mentioned study.

Copy: Director, PHSD